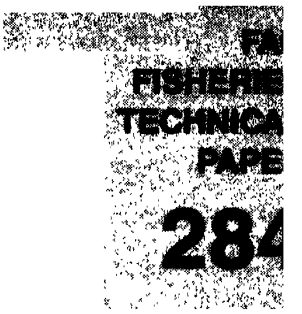
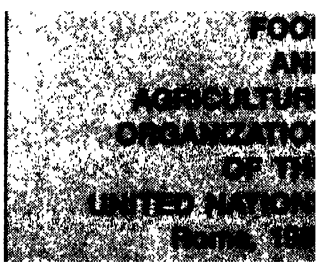
Small-scale fishing with driftnets



Prepared by
Ludvik Karlsen
University of Tromsø, Norway
and
Bjorn A. Bjarnason
Fishing Technology Service
Fishery Industries Division
FAO, Rome



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PREPARATION OF THIS DOCUMENT

This document contains information on how to construct, rigg and fish with driftnets in small scale fishing, and discuss various methods, advantages, disadvantages related to driftnet fishing.

It also gives details (drawings) of driftnets used in more advanced driftnet fisheries from various areas around the world.

This technical paper is especially intended for small-scale fishermen, skippers, net makers, fishery officers, instructors, extension workers and training officers, especially in developing countries, but the same people from industrialized fishing nations are also expected to benefit from reading this document.

Distribution

FAO Fisheries Department
FAO Regional Fishery Officers
FAO Field Fishery Projects
Fisheries Training & Extension Agencies
Small-scale fisheries skippers-owners and Net makers

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ABSTRACT

Driftnetting offers considerable advantages over anchored or bottom-set gillnetting as it can be conducted by artisanal fishermen without any mechanical assistance and regardless of the water depth.

The paper provides guidance for upgrading of fishing technology in relation to gillnetting with emphasis on the needs of developing fisheries, advantages and disadvantages of various gear materials and appropriate fishing methods and technology for optimising fish capture and fishing operations with driftnets.

Simple and easily understood drawings of driftnet fishing gear and methods are provided for the benefit of the fishermen themselves.

For teaching and training purposes, there are technical details and calculations for rigging of driftnets.

Information is provided on gear and methods used in some well-known driftnet fisheries in Europe and the Far East.

Particular attention is given to the selection and calculation of material needed to construct a driftnet and the importance of safe operation.

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1. INTRODUCTION

The authors have tried to make the paper simple and easy to read and understand for the benefit of the fishermen themselves, but also with technical details and explanations for the benefit of those teaching and training others.

For those who need an easier reading and understanding of a document for their teaching or training programmes, FAO has published a training series booklet on "Fishing with bottom gillnets" which can also be used when training fishermen in driftnet fishing.

1.1 Background

The earliest evidence of driftnetting comes from the herring bones in the kitchen middens on the coast of Denmark, and it is believed that the early inhabitants responsible for these middens used nets, and possibly boats for fishing. The nets were probably set or anchored in shallow water close to the shore. By the latter half of the tenth century, herring were being fished along the whole coast of Norway, and by the eleventh and twelfth centuries, vessels with a capacity of 15 to 20 tonnes in weight were used and fishing was carried on by driftnets or by set nets (i.e. anchored nets).

The first great driftnet fishery, however, was carried on by Danes at Schonen in Scania, at the extreme southerly tip of the Scandinavian peninsula, where herring was the chief article of commerce during the twelfth and thirteenth centuries and where the herring trade was controlled by the Hansa merchants.

The Dutch entered early into the fishery and were the first to engage in fishing for herring in the open sea. According to Dutch records, the first large vessel for use in the open sea fishery was built in 1416. The Dutch became the supreme fishers of herring in the sixteenth and seventeenth centuries. They established for themselves a reputation for their cured herring and the wealth of the Dutch and their supremacy at sea in the sixteenth and seventeenth centuries were due in a large measure to the herring fishery. The Dutch fisheries were often interrupted by war and subject to depradation by privateers which ultimately led to their decline.

The Scottish fishery showed a great increase in the nineteenth century and the catch increased from 100,000 barrels to 1,600,000 barrels by the beginning of the twentieth century. The introduction of trawls and purse nets for herring in the latter half of the present century led to the virtual extinction of the herring driftnet fishery. However, the driftnet still remains one of the most effective fishing gear in artisanal fisheries, and is particularly effective in fishing for a range of species whose individual members are widely distributed, and not amenable to economic exploitation by trawl, seine, or purse seine.

1.2 General Description of a Driftnet and Method of Capture

By its general method of capture, the driftnet belongs to the group of passive fishing gears. It is set straight out in the water forming a vertical net wall or barrier of netting perpendicular to the migrating direction of the fish. The same nets may also be used to surround or encircle the fish which may subsequently be herded into the netting. When used in this way, the nets act more as an active fishing gear, and are generally referred to as encircling gillnets.

A general illustration of a driftnet is shown in Figure 1. Its main components are:

- Netting
- Floatline
- Leadline
- Floats
- Sinkers
- Buoys
- Buoylines
- Gavel lines

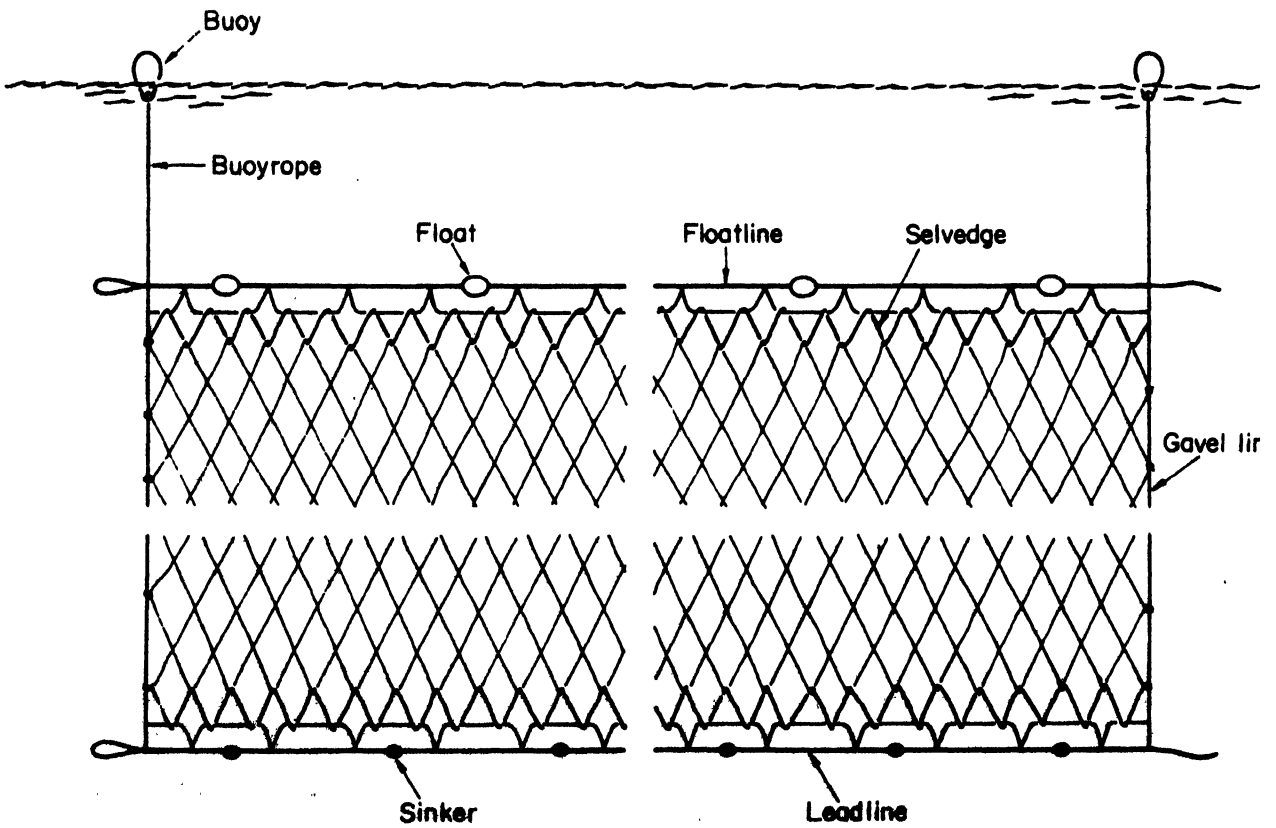

Fig. 1 - Main description of a driftnet

Constructing a driftnet is not very different from stationary setnets, and often the same net may be used for either of the two different fishing methods. In this case the rigging arrangements and operation of the net will be different.

Driftnets may be set as single nets, but most often several nets are tied together into a fleet of nets. Unlike fixed gillnets, driftnets are left free to drift with the water movement. In some fisheries the nets are connected to the vessel by means of a rope or cable at one end of the fleet, in others they are left to drift independently. However, the fishing vessel should always be present at the fishing ground when the driftnets are set for fishing. This is important for the following reasons:

(a) The diurnal migrations of some pelagic stocks can lead to very heavy fishing in a short time, and even to the loss of nets if they are not closely watched.

(b) In tropical waters, the fish will spoil rapidly after death due to the higher temperatures.

(c) The possibility of entangling with other driftnets or other fishing gear in use in the area.

(d) Damage or loss caused by sea pirates or accidentally by passing vessels, especially when surface nets are used.

Driftnets can be set for fishing near the surface, in midwater and near or on the bottom, but when used on the bottom, they are mainly used in shallow waters. They are often more frequently worked than fixed gillnets. They may be set and positioned on the basis of knowledge of migration routes and schooling depths of the fish, or on the basis of known fish concentrations. The time for hauling is often based on the strain or the sinking force exerted on the floats or buoys or by previous experience. Fishing with driftnets is therefore more irregular than fishing with set (anchored) gillnets which are usually left by the vessel for regular intervals.

Because surface gillnets, are often a navigational hindrance to passing vessels, it is very important that the nets are well marked with buoys and dahns during daytime, and lights at nights, especially in areas where ther is a lot of seagoing traffic.

Fishermen must always comply with whatever rules or regulations which are applied by the relevant authorities concerning any restrictions or bans on surface gillnetting in certain areas.

The way a driftnet takes fish varies by different fishing conditions and the shape of the fish's head and body. The main condition is that the fish cannot pass through the meshes of the net, but when attempting to do so draws the net onto itself with

such a force that it cannot release or free itself after. The fish is held tight with the twine of the mesh around its head (snagged), or behind the gill cover (gilled), or as far as around the abdominal and dorsal fins (wedged), or simply caught by their teeth, opercular spines, maxillaries or other projections and drawing adjacent meshes onto itself, twisting and rolling itself in the netting (entangled).

Thus a net of given mesh size may catch fish of different sizes, but the twine material, thickness and the hanging ratio of the net may significantly affect the catch rates.

1.3 Advantages/Disadvantages of Driftnets

One advantage of driftnetting is that it is a very simple fishing method, especially suited for small-scale fishing. It can be performed by small fishing boats with or without simple gear handling equipment, and with a crew of only one or two men.

Driftnetting is also a very efficient fishing method, specially in catching fish near the surface and when the fish are schooling, but it is also used on the bottom, in midwater, and when fish are dispersed.

Another advantage of driftnetting is that the gear can be set in any depth in the water column. Driftnets can also be worked in stronger currents than set gillnets and are more suitable for river fishing. It is of particular importance that the driftnets are not so prone to be fouled by seaweeds or other objects drifting with the current, as a stationary set net would be. In this respect, the driftnet is not as easily seen by the fish as the set net.

One disadvantage of driftnetting compared with stationary (set) nets is that it requires a constant presence of the vessel and thereby the fishermen. Where frequent setting and hauling of the gear occurs, driftnetting is more demanding and laborious than stationary set nets.

Another disadvantage of driftnetting is that the fishing gear is very exposed to damage by passing ships. Surface driftnets therefore must be used with great care if used at all, in areas of marine traffic.

1.4 Types of Driftnets

Driftnets may be classified according to the fish species they are designed to catch and/or how they are positioned in the water column.

In some fisheries, as for example the north Atlantic salmon and herring fisheries, driftnets are very specialized fishing gear, and the nets are carefully designed according to the characteristics of one single species with regard to its size and

distribution. In some areas the nets, even for the same species, may be changed with the fishing season according to changes in fish size and behaviour, water temperature and light and weather conditions. On the other hand, in other areas driftnets are typically multi-species fishing gears (e.g., medium mesh size drift nets in tropical waters). Also, the type of vessel, gear handling equipment and traditions of the fishermen are factors that influence the kind of driftnet to be used.

Because driftnetting is a common fishing method used for catching many different species all over the world, a large number of types or variants of the gear exists. Examples of important fish species that are successfully caught with driftnets and thereby are the cause of special net variants are herring, sardines, sardinella, mackerel, salmon, tuna and shark-type species.

Driftnets are also used to catch fish and crustacea near the bottom in shallow water, i.e., shrimps (India, South and Central America) and sturgeon (Astrakhan, USSR).

With respect to the depth positioning of driftnets we can distinguish between surface driftnets, midwater driftnets and bottom driftnets.

This classification, according to the positioning of the driftnets in the water column, is also closely related to the fish species sought, because the depth has to correspond with the vertical distribution of the fish.

A third way of classifying driftnets is related to how they are rigged to obtain the desired depth. This classification refers to different practices that have been developed with respect to construction, rigging and operation of the driftnets in different countries and for different fishing conditions.

Examples of the most common vessel-to-net attachment of driftnets are shown in Figures 3-5.

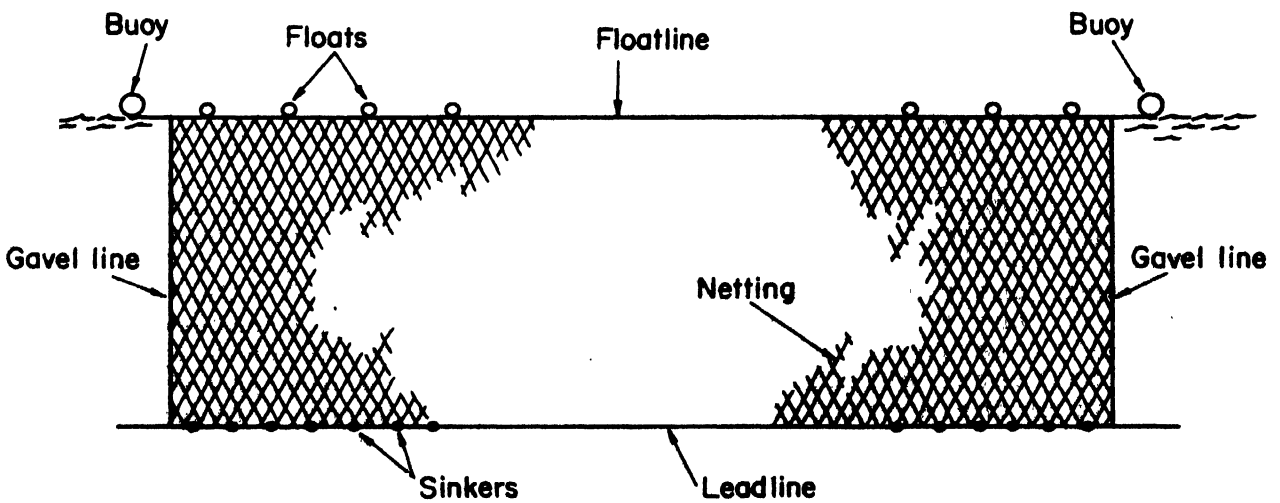

Fig. 2 Surface driftnets

Surface driftnets are specially suited for fishing species that are migrating near the water surface, i.e., salmon and mackerel. The surface driftnet should be supplied with many evenly distributed floats so that the floatline is kept on the surface, even with some weight of fish in the net. In addition to the floats, the surface driftnets should be rigged with marker buoys. There may be one or two buoys used at each net or as few as one buoy every fifth net (in fleets of nets). The function of the buoys is to serve as markers, also as extra buoyancy to prevent the net sinking when there is the additional weight of a large catch. In driftnetting for mackerel and salmon in Northeast Atlantic waters with surface driftnets, the vessel is not usually connected to the fleet of nets. However, it is always present when the net is fishing, and the nets are watched by the crew and examined to determine whether they are catching fish or not. The crew also keeps a look-out for other vessels, and sends out warning signals if a vessel heads towards their nets.

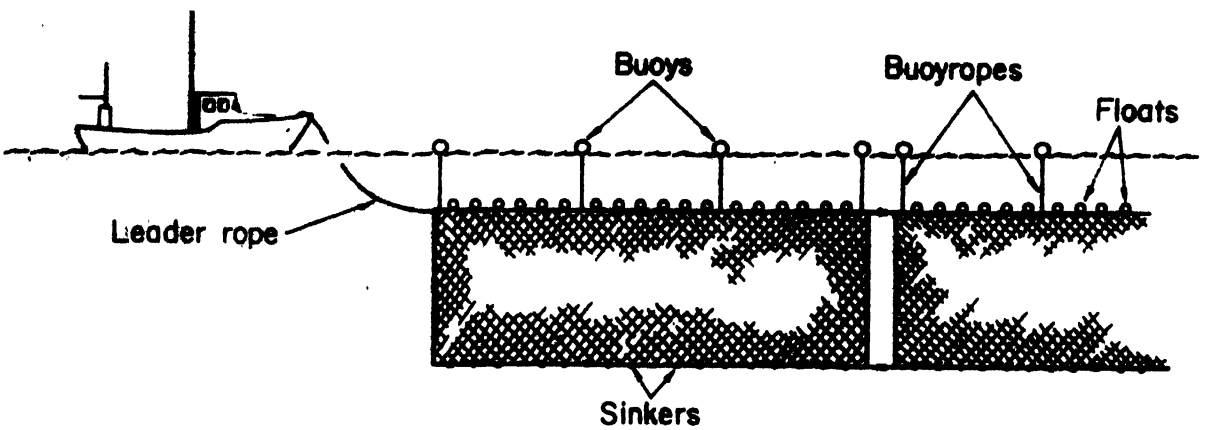

Fig. 3 Midwater driftnet

Figure 3 shows a midwater net that is positioned at some distance from the surface by means of buoys and buoylines attached to the floatline of the net. The total weight of the sinkers and the net itself (in water) must exceed the total buoyancy of the floats and buoyant ropes, but not exceed the additional flotation of the buoys. The advantage of this type of driftnet is better efficiency for catching fish migrating at some distance from the surface or for fish changing depth frequently. This is the most common type of driftnet used for catching

commercially important species like herring, sardine, shark and tuna. The buoyline length should be easy to change according to the changes in the fish distribution with respect to depth. Midwater driftnets may be positioned only half a metre from the surface or as deep as 100 m. Generally, they are connected to the fishing vessel during fishing, as illustrated in figure 3 above.

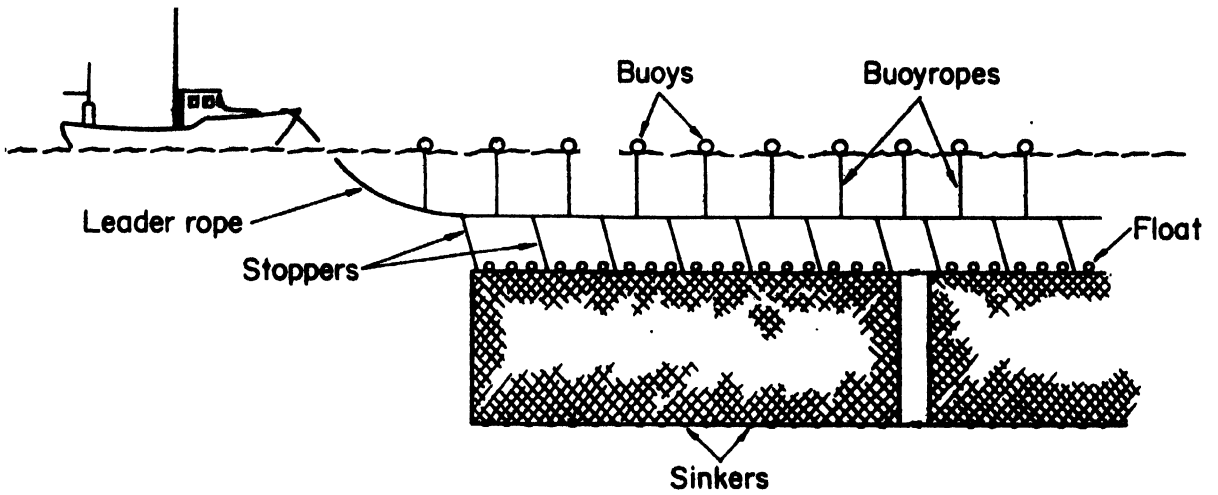

Fig. 4 Traditional Dutch type of herring driftnet

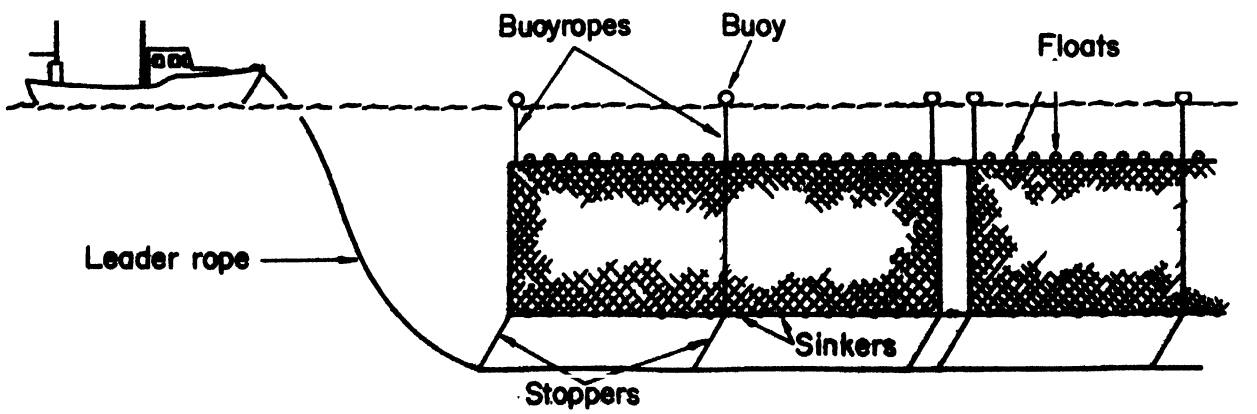

Fig. 5 Traditional Scottish type of herring driftnet

Figures 4 and 5 show two types of midwater driftnets for the traditional large-scale catching of herring. Similar rigging may also be used for modern small-scale fisheries.

Figure 5 shows the traditional Scottish type of driftnetting for herring. Here the leader rope is below the nets and is attached to the fleet with stoppers. The depth of the nets is regulated by means of strops or buoyropes evenly distributed along the net fleet. In strong wind and rough seas there is great strain between the vessel and the fleet of nets, therefore the leader rope to which the nets are attached must be quite strong.

Such an arrangement relieves the nets from excessive tensile stresses and permits easier mechanical hauling. The Dutch type of rigging with the leader rope above the fleet of nets takes into account similar considerations.

The fleets of nets at a depth of 8-10 m or more below the surface are in calm water, even though the waves may be 2-3 m high, the impact from the buoys movements up and down is reduced to a minimum with the leader buoyrope arrangement.

The advantage of the Dutch way of rigging, compared to the Scottish type, is larger reduction of the surface wave forces on the nets when fishing in heavy seas. This is important not only because of the reduced impacts on the fleets of nets but also because it prevents the nets from distorting in rough seas. On the other hand, the Scottish rigged nets are more evenly stretched by the weight of the leader rope (normally of sinkable rope material) along the whole length of the fleet, which therefore become less distorted. The need for leadline sinkers is also reduced and the nets are easier to haul, and the leader rope is less likely to be a hindrance for a passing vessel.

Bottom driftnets normally are much shallower than surface and midwater nets, generally only a few metres high. Their main characteristic is that they touch bottom when drifting. They are often used in such shallow waters, i.e., in rivers, that they reach the surface. Bottom driftnets may be differently ballasted depending on the type of fishery and bottom condition. Shrimp nets are very lightly ballasted on the lead rope, so they have a small negative buoyancy and move along the sea-bed with the lead rope just touching the bottom. On the other hand, bottom driftnets for sturgeon must have more flotation and ballast to avoid the nets collapsing due to the heavy weight of the fish. If the bottom is rough and full of fasteners (like in the River Volga, USSR), the extra ballast weights can be fastened by means of 30-40 cm long bridles or strops. With this rigging the net is kept at a given distance above the bottom and its drift is slowed down because of the friction of the weights along the bottom.

In some tropical countries bottom driftnets in shallow waters are rigged with netting of sinkable material (natural fibre) at the lower part in order to reduce the weight needed to

keep it at the bottom. In some cases no weight is used at all. In addition, a driftnet can be used as an encircling gillnet without any change to the rigging, but only the shooting method in order to encircle a school of fish, as illustrated in Fig. 6.

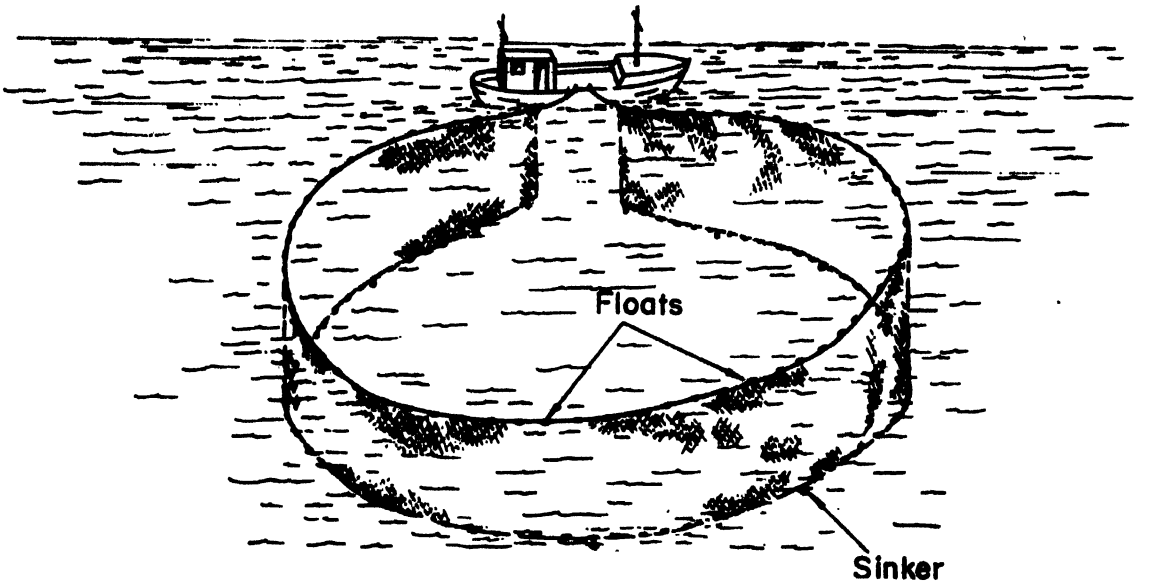

Fig. 6 Encircling gillnet

Here, the school of fish is totally encircled by the net and thereafter chased into the netting by making noise, i.e., from the vessel or as in some tropical waters by splashing the water by hand or with wooden board or club. The encircling gillnets may be used for fishing either on the surface or in midwater.

3. CHOICE OF MATERIALS TO CONSTRUCT A DRIFTNET

Materials for driftnets differ widely according to local conditions, requirements, etc. Consequently, there exists a large variety of different driftnets in the world fisheries. The nets differ with respect to type of materials, shape and dimensions, netting, floatline, leadline, floats and sinkers. The differences in rigging and operation of the (fleet of) nets are very important for the special function of each type. For example, in some tropical areas the hanging of the nets on the floatlines is much slacker than that of the leadline, in order to entangle and catch larger pelagic species. These would normally become snagged, wedged or gilled in that particular mesh size used. Moreover, when trying to entangle larger demersal species near the bottom, i.e. in usually shallow waters, the hanging ratio on the leadline is much slacker than that of the floatline. In such cases the length of the leadlines and floatlines will differ quite a lot.

3.1 Netting

This chapter covers the characteristics of netting according to the following criteria:

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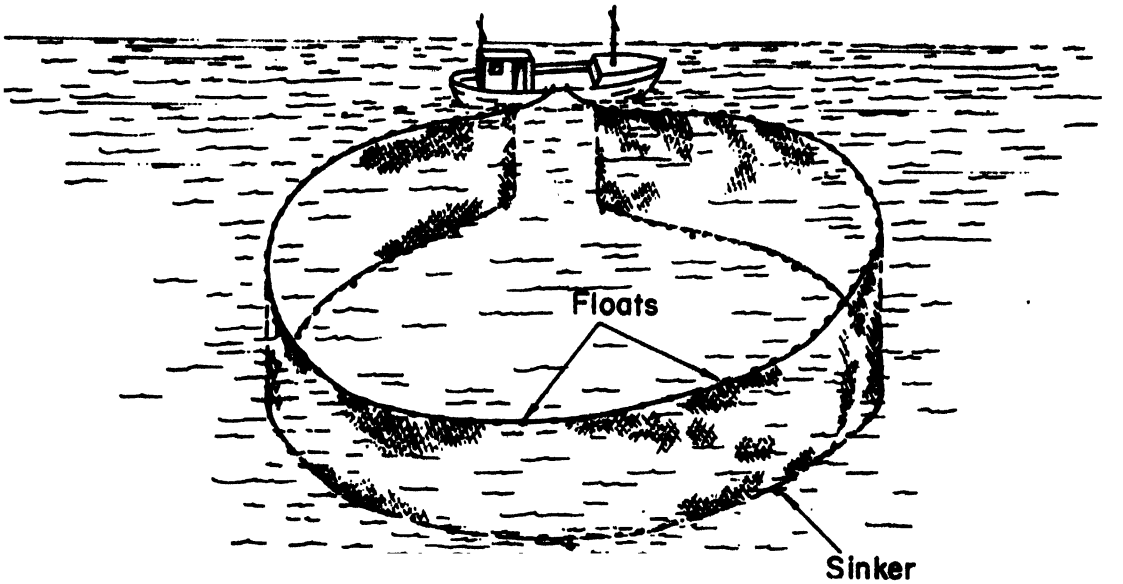

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2.1 Netting

This chapter covers the characteristics of netting according to the following criteria:

- Construction of netting
- Mesh size
- Material (textile, flexibility, stiffness)
- Type of twine
- Size (thickness of twine)
- Colour
- Dimensions of the framelines and hanging of the netting

Selection of the netting should firstly be adapted to the size range and migrating behaviour of the fish species sought, as well as to environmental factors such as:

- Light condition (day/night, weather conditions, etc.)
- Water turbidity
- Fishing depth

Driftnets for multispecies fishing should be so designed that not necessarily the greatest catch (in numbers or weight) but the greatest income should be achieved (e.g., a small amount of a very expensive fish might give a higher income than a much greater quantity of low priced fish). On the other hand, nets designed for research purposes are often designed to obtain samples of as many species as possible regardless of their price or marketing possibilities.

2.1.1 Construction of netting (mesh and knots)

So far only netting with diamond-shaped (rhombic) meshes have been used for commercial driftnets, but netting with hexagonal meshes is now being produced for other types of nets. In general, and always in large-mesh driftnets, knotted netting is used.

The reason for this is not clearly known, as the stability of the joinings (nodes) of knotless netting is quite satisfactory, and several types of joints (nodes) are used by the net manufacturers.

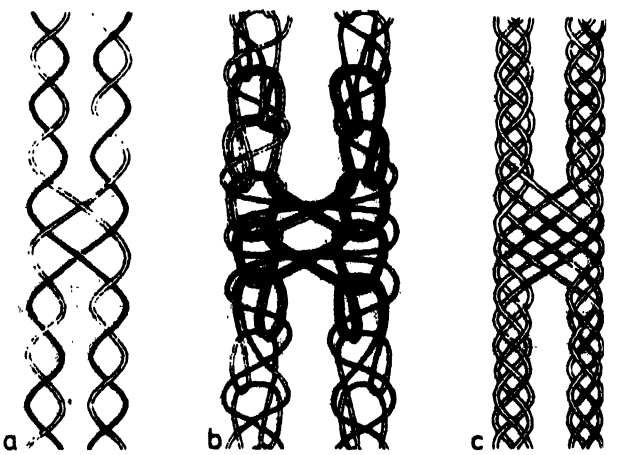


Fig. 7 Examples for the construction of bars and joints (nodes) of knotless netting

The most common joints (nodes) used are (a) the Japanese, (b) Raschel, and (c) braiding techniques, as shown in Figure 7.

As a general rule, the more the netting yarns are connected with each other at the joints (nodes), the more the shape of the meshes will change from the conventional rhombic into a hexagonal form.

In nets of some synthetic material, i.e., monofilament, double knots are common, especially in netting of large mesh-size, otherwise knot slippage would be a problem. However, the need for double knots when manufacturing the net depends on whether the netting and the knots are heat-treated (and the extent to which this process is carried out).

Knotted netting is easier to repair and should normally have more constant and accurate mesh size (double knot) than knottless netting has, especially in small mesh netting of thin twine, as similar knotless netting would be restricted to minimum joints (node) in order not to change the shape of the mesh (Figure 7). On the other hand, knotless netting would be lighter and easier to handle, and production costs lower due to savings of material, abrasion resistance is higher, the joint (node) breaking strength is higher than that of a knot, and netting is easier cleaned and quicker dried. For an exact evaluation of the above points, it must be kept in mind that the term "knotless netting" covers a great variety of constructions which more or less differ from each other in such a way that a general uniformity of properties cannot be expected, and information on practical experience of knotless netting in driftnetting is very limited.

The feasibility of the different kinds of knotless netting for fishing gear in general has still not been thoroughly investigated and new developments of this type of netting can still be expected (Klust, 1984).

The netting orientation may differ and it is not likely that it should have much influence on the catching efficiency. The following considerations are valid concerning the best way of orientating the netting:

- As driftnets are generally much longer than they are deep, it will be an advantage for the manufacturer to orientate the direction (against the "run") lengthwise of the nets. By this, several (the number of meshes (width) of the braiding machine divided by the number of meshes height of each net) nets can be braided simultaneously to any desired length.

- The catching efficiency of entangling nets may be better with the netting oriented with the N-direction (with the "run") lengthwise because of the mesh shape and the slack hanging.

- Any severe tension forces on the netting during hauling will be better matched if the netting is oriented with the N-direction lengthwise.

2.1.2 Mesh size

2.1.2.1 Theory of relative fishing efficiency: For all types of gillnets the choice of the "right" mesh size related to the actual species to be caught is of great importance for the fishing efficiency.

The fishing efficiency of the driftnet for a particular fish species can be demonstrated by means of the relative fishing efficiency curve or selectivity curve. The selectivity of gillnets has been thoroughly studied and dealt with (Hamley, 1975). This booklet only deals with a few factors which affect size selectivity, but in practice many other features than that of the mesh size influence the size range of the fish caught by gillnets.

A typical configuration of such a curve is shown in Figure 8. For a net of a given mesh size the selectivity curve expresses for all actual fish lengths the ratio of the number of fish caught of a certain fish length to the total number of fish. As can be seen from the curve, a net of a particular mesh size catches fish of one particular length (selection range) most efficiently and has considerably reduced catching efficiency of both smaller and larger fish.

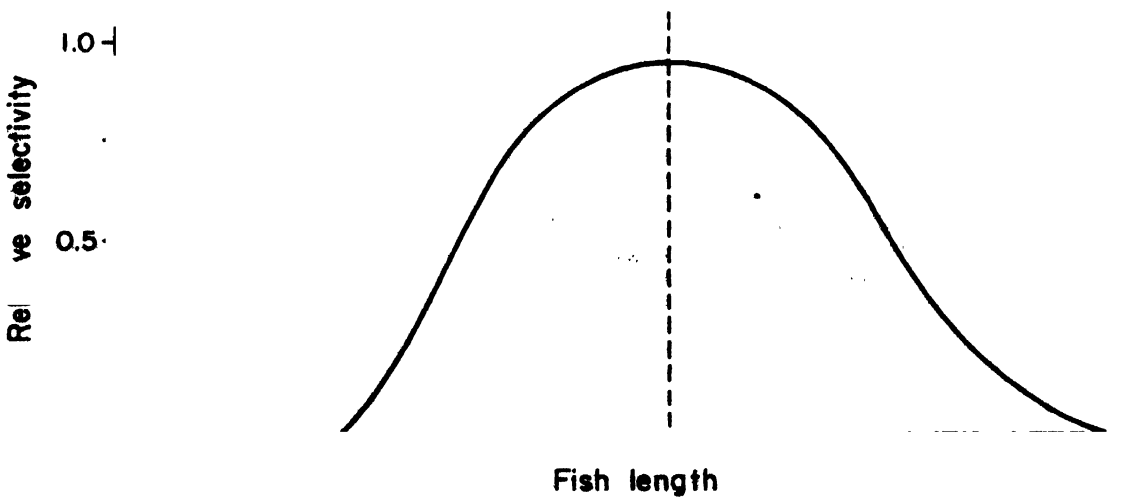


Fig. 8 Typical selectivity curve for a driftnet

To understand why the catching efficiency is so dependent on the ratio between mesh size and fish length, we have to look into how fish are actually caught in driftnets (and other gillnets). Several ways of catching have been observed and identified, as:

(a) Kept by a mesh over the head (snagged)

(b) Kept by a mesh behind the gillcover (gilled)

(c) Kept tightly by a mesh around the body (wedged)

(d) Hung up in the net by teeth, whiskers, fins or other projections or tangled in twisted or folded parts of the netting (entangled).

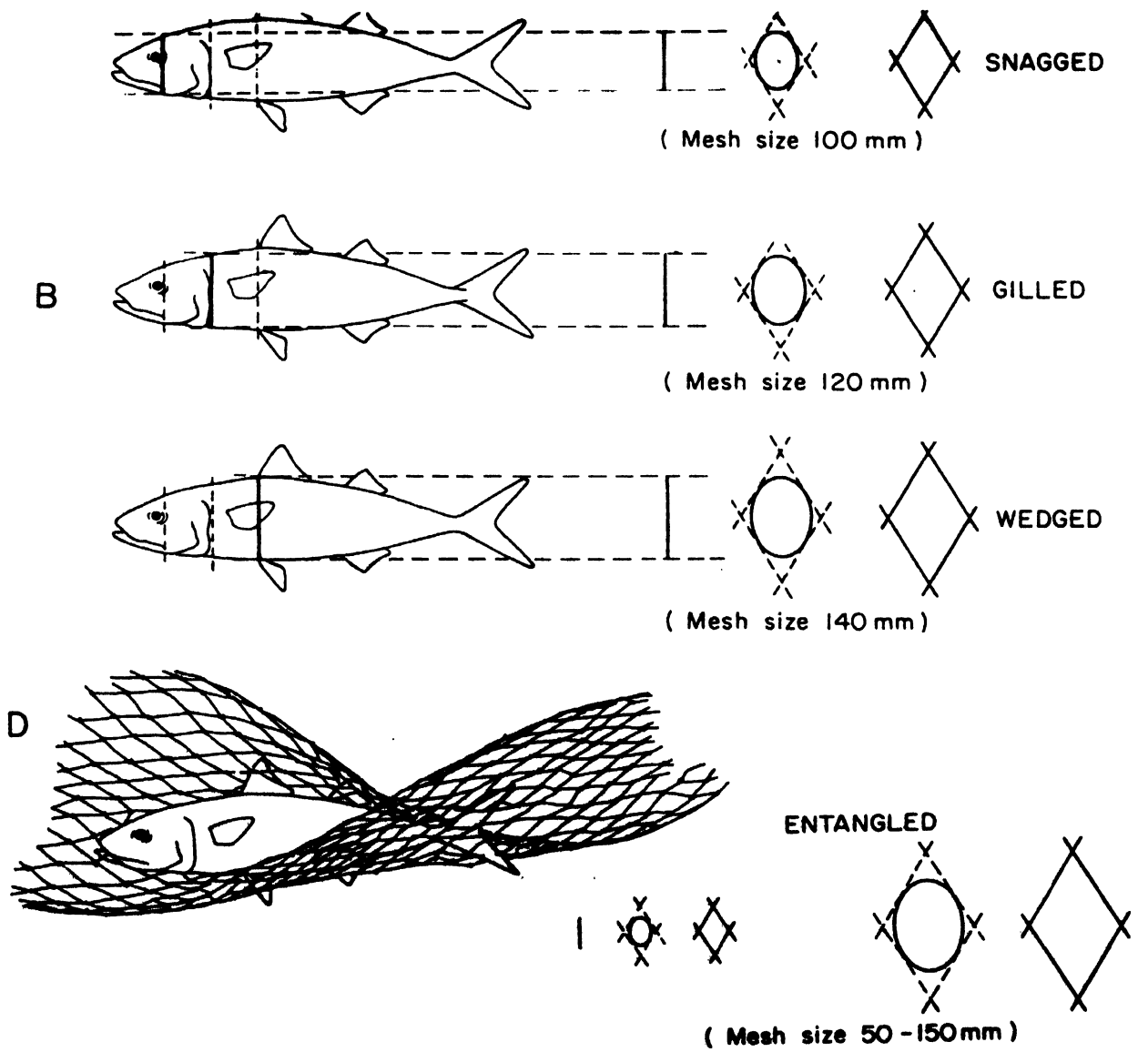


Fig. 9 Four different ways of catching fish with gillnets

Efficient catching according to a, b and c requires a certain relationship between the mesh size and the width of different parts of the body. If the fish is too small, it can pass through the net without being caught in a single mesh, and if it is too large it cannot penetrate far enough into the mesh to get snagged or gilled. Consequently, methods a to c contribute most towards the narrow, high, efficient part of the selectivity curve and thereby the main reason for the importance of right mesh selection, which is dependent on several factors such as the shape of the fish, the softness of its skin and the elasticity of the twine in the net. (Elastic (or reversable) elongation is the part of the total increase in length which is annulled again, either immediately or after a longer period of removal of stress.) The benefit of optimal mesh selection in fishing of a particular fish stock may be two-sided:

(1) If the individual size of the fish in the stock is uniform, it is necessary for a successful catch rate that the chosen mesh size has its maximum efficiency for that particular length of the fish.

(2) If the length of the fish differs a lot, then the average length in the catch can be selected by the choice of the mesh size. In some cases it will be profitable to select the mesh size, corresponding to the largest year class of fish, but, for example, special market requirements may indicate a preference for smaller fish.

Method (d) is not much dependent on the mesh size, and the efficiency of entangling the fish depends on factors mainly related to the type of fish sought (especially its outer structure), the twisting of the twine used (soft or hard lay), the hanging ratio of the net and the ballast and floats used. Entangling nets are generally very loosely hung with few floats and little ballast. They can be made of thinner twine than nets designed to catch the same or similar species by gilling. In some developing countries entangling nets are mostly used as an alternative, because the right material for proper gillnets is not available to the fishermen.

Trammel nets are examples of nets especially designed to catch fish by entangling (see Figs. 27 and 29).

2.1.2.2 Selection of mesh size in driftnets for particular fisheries: The ideal basis for the selection of the mesh size in driftnets for a given fishery is information on the size distribution in the fish stock. The problem is that such information is seldom available, particularly before fishing starts and the nets have to be provided. The mesh size therefore has to be selected on the basis of earlier experience in the same fishery or on the basis of general information from other fisheries on the same fish species.

Table 1

Few examples of mesh size in commercial driftnet fisheries

Type of fish	Area	Country	Mesh size (mm)
Sardine	Mediterranean	France	31
Shrimp	Malabar	India	36
Herrring	Hokkaido	Japan	49-52
Herring	English Channel	France	53
Herring	North Sea	Norway	52-60
Herring	North Atlantic	Iceland	63
Spanish mackerel	Gulf of Siam	Thailand	82-100
Salmon	North Pacific	Japan	121
Salmon	Puget Sound	USA	125-200
Salmon	Barent Sea	Norway	120-135
Salmon	Baltic	Germany	160
Tuna, shark	Indian Ocean	Sri Lanka	150
Shark	Inshore waters	Australia	150
Shark	Coastal waters	Mexico	300
Multispecies	Shallow waters	Bangladesh	75-220
Multispecies	Shallow waters	Sri Lanka	100-180
Bluefin tuna	Mediterranean	France	240

In the table above some examples and ranges of mesh size in commercial driftnets for given species and fishing areas are shown. The table gives an example of the wide range of important species fished with driftnets, and that within the different fisheries the mesh size can have a large range. The smallest mesh size is only 31 mm for a bottom driftnet for shrimps, while the biggest is almost eight times larger; 240 mm in a driftnet for yellowfin tuna.

In the following sections, we shall take a closer look into important factors in the selection of mesh size for the most abundant species groups and to the importance of accurate choice.

2.1.2.3 Clupeid driftnets: The mesh size in clupeid driftnets should be carefully considered for several reasons. One reason is that clupeids generally school in year classes and the size of the individuals is therefore fairly uniform. Mesh sizes that are not closely related to the size of the fish sought would therefore be very inefficient. This is even more so because clupeids are fairly smooth (soft skinned) fishes with no tendency to entangle. Another reason is that clupeids are small fish that have to be caught in large numbers to give a sufficient economic return. The chosen mesh size should therefore be small enough to prevent for large-scale wedging, i.e., that the fish cannot penetrate too far into the mesh with its body. This would also complicate the release, and clupeids have soft skin that can easily be cut and damaged by the twine of the netting, also emphasizes requirements for not too large meshes.

Even a large enough mesh size to allow only gilling, would in the Norwegian clupeid fisheries not be advisable because of the release problem, and the possible damage of the fish. For this reason, the mesh size in that particular driftnet fishery is so chosen that the mesh size for most of the fish cannot pass the head, but fastens over it (snags). One problem with choosing too small a mesh size is that it reduces the catching efficiency of the net. Another is that a lot of the fish snagged may escape from the net during hauling.

Some recent experiments in Norway give an example of the problems associated with the choice of correct mesh size for clupeid driftnets. It was found that the mesh size used, (60 mm) according to the common practice of the fishery, was too small. By fishing on a stock of herring ranging in individual length from about 300 mm to 400 mm, it was found that even with 66 mm mesh size, which was more efficient in catching larger herring, a lot of the largest species (about 30%) were lost during hauling, even when special care was taken when retreiving the nets to reduce the loss (Venvik, 1982).

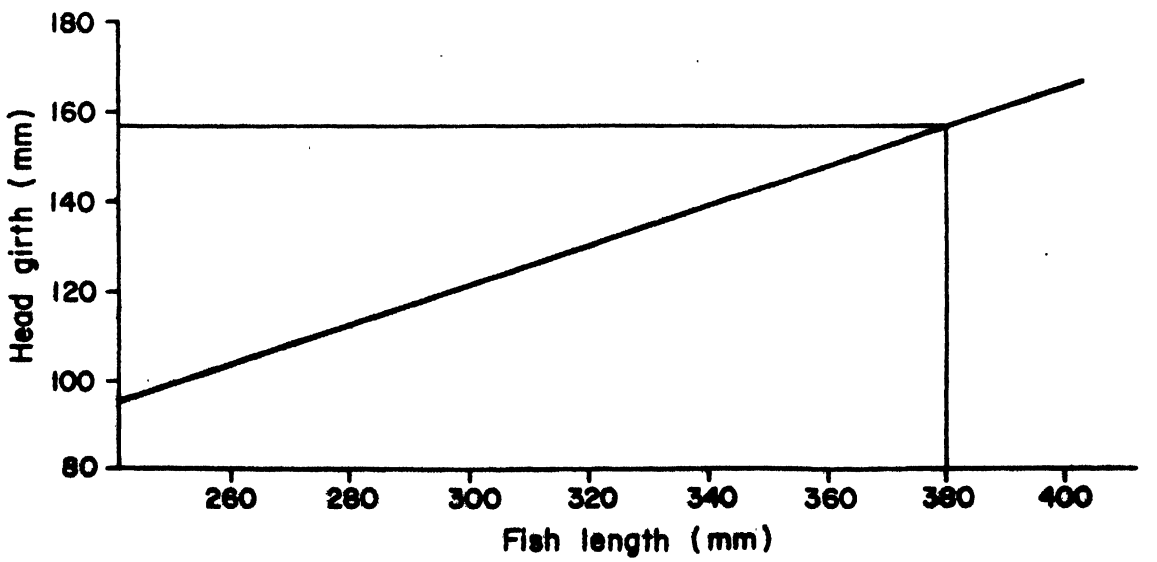


Fig. 10 Girth of herring as a function of body length

In Figure 10 the mean girth as function of the length of the herring (stock) in these experiments is shown. A lot of the largest herring of the stock fished had a length of about 380 mm. From the figure it appears that the mean head girth of this herring size is about 157 mm. The ratio between the half head girth 157:2 and the mesh size 66 is therefore 1.19. This explains why so many of the herring were lost. The conclusion of these experiments is that the most efficient mesh size for catching large herring of 350-400 mm length should be larger than in the commercial nets used (i.e. about 70 mm).

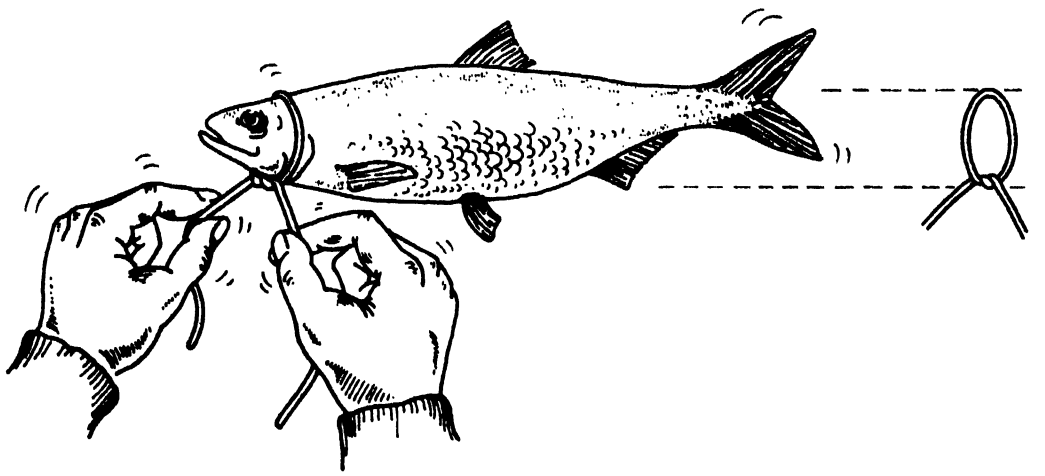


Fig. 11 Measuring the head girth

2.1.2.4 Salmon driftnets: Unlike clupeids, salmon is a large and expensive fish of which only few individuals have to be caught (in small-scale fisheries) to give a good commercial return. The most important consideration for the choice of mesh size in salmon driftnets is therefore that the salmon shall not be able to release itself from the netting. The mesh size should be large enough to be drawn onto the body of the salmon (gilling or wedging) and firmly enough to prevent subsequent escape. In addition, salmon gillnets should be loosely hung so the salmon can entangle itself in the netting, thereby increasing the probability of capture. The differences in mesh size used in salmon gillnets shown in Table 1 are mainly due to different size of the salmon in different fisheries, and/or market demands as large salmon fetch a better price than the smaller ones.

2.1.2.5 Tuna driftnets: Also, tuna driftnets differ considerably in mesh size because they have to be adapted to different size of the tuna species. Thus multi-species tuna driftnets (skipjack, yellowfin) have usually a mesh size of about 150 mm, while nets for the larger bluefin have a much larger mesh size (240 mm).

2.1.2.6 Shark driftnets: Shark stocks will usually have a wide range of species composition and size distribution in the more shallow coastal areas where they are exposed to small-scale driftnet fisheries. Therefore, the choice of mesh size is less dependent on maximum catch considerations than, for example, market demands. In some mesh size experiments in coastal Australian waters with monofilament driftnets it was demonstrated that better shark catches could be taken with 150 mm mesh nets than with 100 mm or 200 mm mesh size, as shown in Table 2 below (Lyle and Timms, 1984). As shown, the experiments also demonstrated that mesh size influenced both the species and size composition of the catch.

Table 2

Different Mesh size of nets for sharks

Mesh size (mm)	100	150	200
Average shark catch (kg)	2 306	3 085	2 470
Mean fork length (cm)	61.8	74.7	90.1

Driftnet experiments in Bangladesh (Pajot, 1980), have also proved the influence of mesh size on the size of the sharks caught. The catch rates demonstrated as follows:

Table 3

Mesh size (mm)	100	125	150	180
Number of sharks caught	15	100	76	53
Average weight (kg)	3.9	2.5	3.2	7.0
Total weight (kg)	59.3	251.6	241.2	372.3

The most probable explanation for the larger shark species in the 100-mm net than in the 125-mm or 150-mm is that the sharks were entangled in the smallest size mesh. In the nets of 125 mm mesh size, the smallest shark is caught by wedging, gilling or snagging. This is also the case for the nets of 150-mm and 180-mm mesh sizes, which are more suitable for the gilling of larger species. Another possible explanation for the catches of larger sharks in small mesh nets, is that these nets may have caught smaller fish first which then attracted the sharks. In some places fishermen, fishing with gillnets for sharks, tie bait fish to their nets before setting them.

2.1.2.7 Driftnets for catching various fish species: These driftnets are most efficient in shallow waters where the nets are also fishing near the bottom. The mesh size in such nets may vary greatly also within the same fishing area. It is very difficult to decide upon any "optimal" mesh size because the relative occurrence of species of different sizes may vary considerably. However, experiments in Bangladesh with large mesh nylon (PA) driftnets showed a considerable increase in catches with larger mesh size, as shown in Table 4 below (Pajot, 1980):

Table 4

Mesh size (mm)	100	125	150	180
Average catch/net set (kg)	9.7	29.7	32.25	52.1

The Table clearly demonstrates that 100-mm meshes are too small for the species sought (altogether 19), and also indicates that entangling plays a minor role for catching. These conclusions are supported by the fact that of two of the larger species present, Indian salmon with an average weight of 10 kg, and tuna (7-10 kg), none were caught in the 100-mm mesh driftnet.

2.1.3 Type of textile

As in other types of gillnets, several types of textile can be used for the twine to be used for driftnets. In the past, natural textiles such as cotton (clupeid nets), linen (salmon) and ramie (multispecies) have been widely used, but now synthetic materials are predominant. The main advantages of the synthetic fibres, compared to the natural ones, are that they last much longer and are comparatively much stronger. "Synthesis" is the scientific and technical term for the chemical process by which chemical elements or simple basic substances are combined and built up to complicated and completely new materials with new properties. Man-made fibres made of such simple substances as phenol, benzene, acetylene, prussic acid, chlorine etc., are, therefore called synthetic fibres.

The following chemical groups or classes of synthetic fibres are used for fishing nets:

Synthetic fibre	Symbol
Polyamide	PA
Polyester	PES
Polyethylene	PE
Polypropylene	PP
Polyvinyl chloride	PVC
Polyvinylidene chloride	PVD
Polyvinyl alcohol	PVA

These technical terms indicate the various fibre-forming substances of the different groups. The symbols or abbreviations of the terms, adopted internationally, should be kept in mind because they are frequently used in technical literature and also in this Paper.

The most common synthetic material in driftnets is polyamide (PA), also called nylon. The advantage of nylon (PA), compared to materials made of other synthetic fibres is that it is more elastic. The good elongation of PA twines also has been found to increase the selection range, i.e., the width of the selectivity curve, as shown in Figure 8. The reason is that the mesh stretches and has an effectively larger size under tension from a fish when it swims into the mesh. In practice this means that the net efficiency is increased for fish larger than the optimal size for the measured mesh size. This positive effect on the efficiency is related to the twine thickness and the size (swimming force) of the fish, as these two factors influence the elasticity and tension on the twine. This effect of the elongation of meshes is of most importance for fish that normally are snagged, gilled or wedged.

On the other hand, the elongations of nylon (PA) also may have some negative effects. In Polish comparative experiments (Zaucha, 1964) it was concluded that polyvinyl alcohol (PVA) was preferable to nylon (PA) in large-scale herring fisheries because too many herring were wedged in (PA) nylon nets, resulting in both increased release work and severe damage to the herring. PVA twine has a much lower elongation than nylon (PA) twine and is therefore to be recommended in fisheries where wedging is not preferable, as in some herring and sardine fisheries.

Although other synthetic materials such polyester (PES) and polypropylene (PA) are used as driftnet materials, they do not show particular advantages compared to polyamide (PA). Polyethylene (PE) is a cheap material which, in recent years, has been tried in gillnets. In comparative experiments with large-mesh multispecies driftnets in Bangladesh (Pajot, 1980), polyethylene (PE) nets showed equal efficiency with polyamide (PA) nets of the same size. However, the PE nets were so easily torn and damaged that for this reason they were considered not comparable with PA nets, although they were about 20% cheaper. In Norway and other Nordic countries, monofilament PE gillnets also have been tried without much success, compared to monofilament (PA) nets.

Of the natural fibres, cotton has been the best material for driftnets. Cotton has a relatively good tensile strength and has a low elongation (10%) compared to some synthetic materials. As described earlier, the low elongation may have a good influence of the quality of the catch, as the meshes do not penetrate so far onto the body of the fish (which is also due to the fact that the twine is comparatively thicker than that of synthetic

material for a given breaking strain). It will also reduce the effort of releasing the fish from the net, which is of particular interest in herring and sardine fisheries. The disadvantage of cotton is that it rots, and therefore must be frequently dried and/or treated with preservation agents.

2.1.3.1 Identification of synthetic fibre used in driftnetting: Several methods may be applied for the identification of synthetic fibre (Klust, 1982).

In this booklet we will deal with only two methods, namely water and burning tests.

(i) Water test (Klust 1982). It is advisable to start the identification with this test,. In a short piece of the netting yarn a simple overhand knot is tied. The piece is put into a vessel filled with water. Air bubbles in the material must be squeezed out by hand under water. Preferably a wetting agent (e.g. 1 g/l Lissapol N or Nekal BX) should be added to the water. The water test serves to classify the netting material into two groups, i.e. those synthetic fibres which float in water (PE and PP), and those which sink (all other kinds of synthetic fibres).

(ii) Burning test. For this test only clean flame and two forceps are needed. The best source of flame is a Bunsen burner or, if a gas supply is not available, an alcohol lamp, but even a cigarette lighter may be used. The following should be observed: the reaction of the netting material in the flame, and after removal from the flame, the smell of the gaseous products (smoke), and the residue. When synthetic fibres were introduced into fishing the burning test was very often used by fishermen as it is the simplest test for distinguishing any synthetic fibre from cotton. Cotton and other vegetable fibres, and also most of the man-made fibres made of regenerated cellulose, burn rapidly in the flame and continue burning after removal from the flame. They have an after glow, the smell of smoke is similar to that of burning paper and the residue consists of a small amount of fine ash. The synthetic fibres considered here are thermoplastic. They shrink and melt in the flame, the melting substance drips from the flame, mostly forming a bead or a hard, irregular residue.

The following burning characteristics of synthetic fibres used in gillnets are also copied (Klust, 1982):

	PA	PES	PP	PVA
In flame				
Melts			x	
Shrinks			x	x
Burns with light flame	x		x	xx very rapidly
Smoke white	x			
Black/Sooty		x		
Melting drops fall	xx (yellowish)	x		
Curls				
After Flame				
Burns			slowly	
Stops burning			continue to burn slowly	continue to burn rapidly
Melting drop bead may be stretched to fine thread	x			cannot be stretched
Residue				
Hard uncrushable bead	yellowish	blackish	brown/black	brown/black
Shape	round		round	irregular
Smoke Smell	celery-like fish odour	sooty/oily sweet/ faintly	burning asphalt like wax or paraffin	sharp sweet like chlorine

2.1.4 Types of twine

Mainly three types of synthetic twine are actually used in netting for driftnets, namely, multifilaments, monofilaments and multi-monofilaments.

2.1.4.1 Multifilament twine for fishing nets are mainly made from either continuous filaments or staple fibres.

A. Continuous filaments

These are fibres or practically infinite length having a silk-like appearance and are produced in different degrees of fineness. The thickness of the single filaments in yarns for fishing nets is in the range of 0.66-2.2 tex, i.e., the weight of

1 000 m is from 0.66 g to 2.2 g. These filaments are smooth and have a high degree of lustre unless treated by chemical means, and contains exactly the same number of single filaments in the cross section over the whole length.

B. Staple fibres

Staple fibres are not much used in driftnets of synthetic material. These are discontinuous fibres, usually prepared by cutting filaments into lengths suitable for the yarn spinning process. Their fineness is similar to that of continuous filaments, their length generally ranges from 40 to 120 mm, or more.

Staple fibres are bound by twisting to form a spun yarn. It is only by the pressure caused by this twisting that the short fibres are held together and form a continuous strand which is called a single yarn. In this regard, synthetic staple fibre yarns resemble cotton or wool yarns. Netting yarns made of staple fibre have a rough surface owing to the numerous loose ends of fibres sticking out from the twine. This hairy nature decreases slippage of the knots. Spun staple fibre yarns have a lower tensile strength and higher extensibility than continuous filament yarns made of the same kind of synthetic fibre material.

The filaments of both continuous and staple fibres can be made to any thickness, but normally in nylon, it is produced with a magnitude of 23 tex (210 denier) thickness. The multifilament twines are smooth and with lustre (when not treated chemically). The stiffness of multifilament twines is dependent on the twisting hardness, i.e. number of twists per metre, and on how it is treated with impregnation agents.

2.1.4.2 Monofilaments

The term monofilament, in the proper sense, means a single filament which is strong enough to function alone as a twine without having to undergo further processing. This is the essential difference to the fine continuous filaments and staple fibres described above which cannot directly be used (as individual fibres) for netting. In particular, transparent PA monofilaments are used as single filaments for fine gillnets. In practice, however, the term monofilament is a more general term covering all coarse filaments with large diameter and stiffness and a wiry character (synthetic wires). They mostly have a circular cross-section and diameters between 0.1 and 1.0 mm or more, but monofilaments with oval or flat cross-section are also manufactured, i.e. 0.17 + 0.34 mm or 0.24 + 0.48 mm.

The usual method of measuring the circular type of monofilament is to denote the diameter in millimetres. Thus, a monofilament twine No. 0.6 has a diameter of 0.6 mm. The monofilament twine appears as a transparent material, and is therefore less perceptible in water than multifilaments. Unlike

multifilament nets, which can be coloured by dying, the colour of monofilaments is determined during the production process. It is most often grey, blue or green.

Single monofilament for driftnet purposes of diameters from about 0.2 mm to 0.8 mm are mainly used. Single monofilaments are rather stiff and therefore the nets become bulky and more difficult to store and handle.

In driftnets, monofilaments can be used both as single filament (monofilament) or as multifilaments(multi-monofilaments or foulded monofilaments).

2.1.4.3 Multimonofilaments (Folded Monofilaments)

A number of monofilaments may be twisted together to form a twine. There is no special international standard term for this type of twine, but in this paper it is called multi-monofilament twine. Sometimes these are described as folded or twisted monofilament twines.

In some countries, the third term monotwine (3 monofilaments fibres folded together) is used. It is explained here for informational purposes only but, of course, 3 monofilaments fibres folded together are also multi-monofilaments or folded monofilament twine.

The multimono twine has from 4 to 10 or more single filaments, which are loosely folded or twisted together to form the final twine. The advantage of nets made of multimono-filaments, compared to the single monofilaments, is that they are more flexible and not as stiff, therefore, easier to handle and store on board the vessel, and easier to mend or repair.

With respect to fishing efficiency, a number of experiments and comparative experience from commercial fishing has indicated the superiority of monofilament products (mono and multimono twine) to multifilament twines, in fishing under different sea colour conditions and shallow waters.

The following experiments were conducted by Mr. McNeilly off the coast of Baluchistan in 1981-82, to measure the relative efficiencies of coloured multifilaments, monofilament, and multimonofilament gillnets.

The mesh sizes in all the nets were similar, and the area and sea conditions were the same. Nets were set in one string, all net positions were rotated when measuring their efficiencies, and it was noticeable that monofilament and multimonofilament caught slightly more when being flanked by white or coloured multifilament nets.

MATERIALS	COLOUR	CATCH RATE
Multifilament	white	0.156 Kg per running metre
"	green	0.296 Kg " " "
"	brown	0.290 Kg " " "
Monofilament	transparent	0.432 Kg " " "
Multi Monofilament	green/grey	0.462 Kg " " "

This is shown here only to demonstrate the superiority of mono and multimonofilament nets over nets braided from multifilament fibre in one particular area, and not as a test of colour for multifilament nets, however, in the prevailing conditions where the water was generally muddy and most of the fishing conducted during darkness, the white multifilament nets caught significantly less than the green and brown multifilament nets.

The disadvantage of nets braided from mono or multimonofilaments, compared with multifilament twine (apart from the handling problem of monofilament nets) is that they are generally more expensive.

Both multifilaments and monofilaments are today widely used in driftnet fisheries. In some fisheries, like the Norwegian salmon driftnetting, monofilaments are exclusively used because of much better catching efficiency. In others, like herring driftnetting, multifilaments are more popular than monofilaments. In most fisheries it is difficult to give general advice, and availability, cost and earlier experience are often the basis for the choice.

2.1.5 Size (thickness) of the twine

The twine size also has been found to have a considerable effect on the fishing efficiency of driftnets. One explanation is that a thinner twine is less visible to the fish. For driftnets which most often are fished near the surface with good light conditions, the effect of visibility is more important than for bottom set nets. The other explanation for the increased catching efficiency of thinner twine is that it is more elastic and flexible. The effect of the twine size has been demonstrated in several fishing experiments, both with small-mesh and large-mesh driftnets. An American experiment with monofilament gillnets of different twine sizes, a relationship between the twine size and the size (length) of Peamouth and Yellow perch caught was found (see Table 5 below)(Hamley, 1975).

Table 5

Twine diameter (mm)	0.267	0.133
Peamouth length (cm)	16.5	20.5
Yellow perch length (cm)	14.5	16.5

It should be noted that the experimental twine of 0.133 mm is very thin, thus allowing for a considerable stretching of the twine. When more standard twine thicknesses are used in small-mesh nets, the tension on the twine created by the small fish swimming force is so small that mesh size selection due to elasticity of the mesh bar is hardly possible.

In large-mesh driftnets, the effect of twine thickness has been demonstrated in recent comparative fishing experiments in Bangladesh and Sri Lanka (Pajot, 1980, 1981). In the Bangladesh experiment with 180-mm mesh size multispecies driftnets, the average catch with the experimental 27-ply (210/27) multifilament nylon (PA) nets was much higher than with otherwise similar traditional 45-ply (210/45) nets. In similar experiment in Sri Lanka, 21-ply (210/21) nets had on average about 30% better catching efficiency than the traditional 27-ply (210/27) nets. Both these experiments demonstrated the value of decreasing the twine thickness in the traditional large-mesh driftnet fisheries of this region. The cost of the fishing gear is also less because thinner nets are much cheaper. (The price is about proportional to the weight of the netting.)

One problem that may be associated with the reduction of the twine thickness is that the meshes may break more easily because of the struggle of large fish or stresses imposed during hauling. However, in the experiments referred to, this was not found to be a problem possibly because the traditional nets were of heavier twine than necessary and very little repair was necessary for the thinner twined nets. One other problem with thinner twine is that it cuts into the skin of the fish more easily, and thereby damages it. This problem must be carefully considered in the fisheries where fish are mostly wedged, and it is related to the type of material and fibre of the twine, as described earlier.

In Table 6 below examples of twine size in commercial driftnets for some important species are given.

Table 6

	Material	R tex	Ply-denier (x/210)	Appr. dia. (mm)
Herring	PA	150	6	0.4
Spanish mackerel	PA	400-550	15-21	0.65-0.80
Salmon	PA	250-830	9-33	0.5 -0.13
Salmon	PES	400	13	0.63
Multispecies, large-mesh	PA	680-1 515	27-60	0.85-1.43
Bluefin tuna	PA	2 660		1.9

2.1.6 Colour

With respect to the colour of driftnets there seems to be no uniformity of the opinions of what is best for the fishing efficiency. Nor does there exist any scientific proof of what is the optimal colour of the nets even for defined fishing conditions. Also, the fact that even within the same type of fishery (species and season) the preferred colour of driftnets (and other gillnets) is often changed from one year to another, indicating that the effect of colour is not clear. However, photographs of different coloured nets in different light and water conditions have shown that the contrast of the nets to the background is of importance for their visibility. Driftnets that are operated in clear waters near the surface during daylight consequently should be bright and not dark coloured, as they will normally be seen against the bright surface. For the same reason driftnets that are fished in muddy waters, deeper or close to bottom and during the night should be darker. The results shown on page 27 give definite support to this criteria to be taken into account when choosing the colour of driftnets.

One problem associated with the colour of driftnets is the magnitude of colours offered by the net suppliers. In addition to confusing the fishermen about the "right choice", this undoubtedly increases the cost of the nets because of extra requirements for manufacture and stockholding.

2.1.7 Dimensions of framelines and hanging of the netting

The length of nets when mounted is given by floatline and/or leadline length. One reason for specifying the length of the framelines is that the requirements for floatline and leadline may be different. The depth is generally given in the number of meshes.

The optimal dimensions of a particular driftnet are dependent on fish species sought, and fishing conditions. The length of each net is not regarded as important for the fishing efficiency as several nets are usually tied together in a fleet

of nets. On the other hand, the length of the fleet is considered to be of importance in conditions where the fish may easily detect the nets and try to avoid them. Also, the distribution of the fish influences the optimal length of the fleet of nets because scarce and variable distribution tends to favour a longer fleet of nets, and if the fish are more concentrated or in schools, shorter fleets of nets are preferred. This is subject to other constraints such as the maximum workable length and the expected catch rates.

In commercial fisheries, the length of single mounted driftnets varies from about 20 m to several hundred metres. An extreme example is the Australian shark driftnet of 1200-m length (Lyle and Timms, 1984). Most commonly, however, the length of each mounted driftnet is in the range of 20-50 m. The length of fleets, which is the length of each net multiplied by the number of nets, used in commercial driftnet fisheries, is dependent on many factors, such as the fishing efficiency, economy and handling considerations. The fleet may therefore consist of from two nets to as many as 150. The latter is common in Norwegian mackerel and salmon fisheries with vessels 8-15 m long, and a crew of 2-3 men. With each net about 30 m length, the total fleet length in this case will be about (150 x 30m) = 4.5 Km.

The hanging ratio E, is defined as the length of the framelines (L) relative to the stretched length of the netting (L_o), with N as number of meshes and L_m as the mesh size, $E = L/L_o = L/(N.L_m)$.

As an example a net of 60 mm mesh size and 1840 mesh long or 1840 x 0.06 m = 110,4 m hung to a 60 m frameline, L = 60 and L_o= 110,4 m; E = 60/110,4 or E = 0.54.

Nets meant for catching fish by snagging, gilling or wedging should be hung tighter (i.e., more stretched) with a high hanging co-efficient than typical entangling nets. In practice, the hanging ratio for entangling nets is generally in the range of E = 0.5 or less, while for gillnets it generally ranges from E = 0.5 to 0.8.

It is not uncommon to hang the netting unequally to the floatline and leadline, in which case it is more common to hang the nets with a larger hanging coeffficient on the leadline. The advantage of a longer leadline (larger hanging coefficient) is that jellyfish, seaweed or other flotsam does not entangle so easily in the net during fishing and/or falls out more easily during hauling. There are also some claims that larger fish may get entangled more easily in the nets with increased hanging ratio at either frameline (see chapter 2). One disadvantage of having considerably different lengths of framelines is that the netting may be more strained during hauling.

In Table 7 the hanging coefficient of both framelines in some commercial driftnets are given. Note the great difference in hanging ratios of herring and salmon nets, and that there is no general agreement about the relative hanging ratios of floatline and leadline. An extreme example in this respect is the French herring driftnet with totally stretched netting (E=1) at the leadline, and the Italian Mediterranean driftnet for swordfish with the same stretching of both float and leadline (E=1).

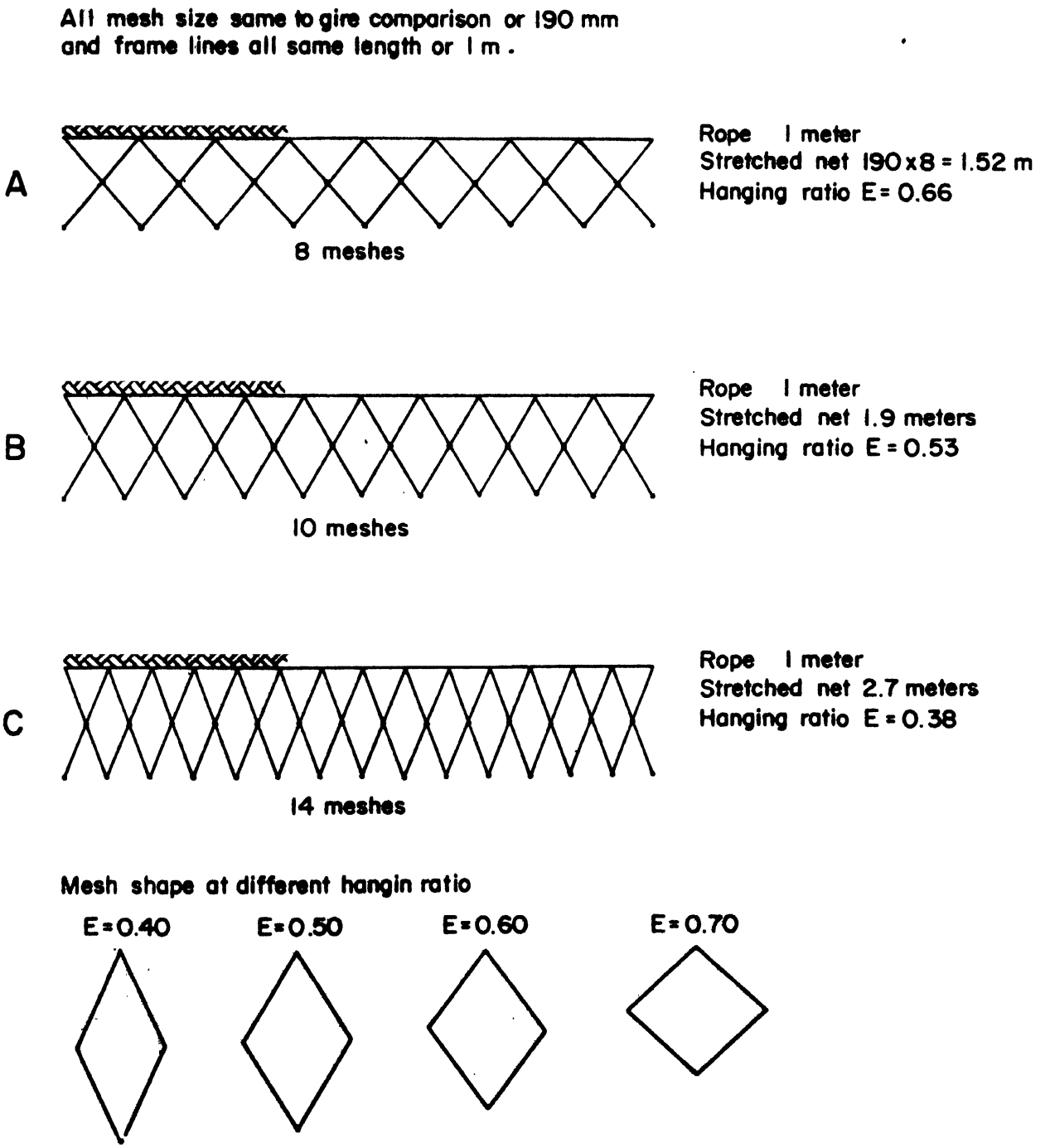


Fig. 12 Different hanging ratios for driftnets

Table 7

Fish species	Country	Hanging ratio (E) Floatline	Leadline
Salmon	USA	0.42	0.44
Salmon	Japan	0.44	0.42
Salmon	Germany	0.50	No leadline
Spanish mackerel	Thailand	0.50	
Shrimp	India	0.50	0.51
Multispecies	Bangladesh	0.50	
Multispecies	Sri Lanka	0.60	0.60
Shark	Australia	0.63	0.63
Bluefin tuna	France	0.63	0.69
Herring	France	0.66	1.0
Herring	Japan	0.69	0.69
Swordfish	Italy	1.00	1.00

It is a general belief, that also has been confirmed in fishing experiments, that the hanging ratio has a considerable influence on both the catching efficiency and the fish size selectivity of driftnets. The main finding is that looser hung nets (low hanging ratio) catch more and larger range of fish length than the same nets more tightly hung. There are also more fish entangled. In Table 8 this is demonstrated by catches of tilapia in nets with three different hanging ratios (Hamley, 1975).

Table 8

Hanging ratio	Average No. caught/day	Percent tangled	Size range of catch
1.00	9.3	0	18-23 cm
0.50	29.5	24	13-23 cm
0.33	81	80	8-22 cm

When examining the effect of the hanging ratio it should be borne in mind that reduced hanging ratio also reduces the mounted length of the net (with the same length of netting), and if the hanging ratio is less than 0.7, then it will also reduce the effective fished area. When considering the catch and percentage of fish tangled in Table 8 it should also be borne in mind that different mesh sizes, twine thickness, floatation, ballast and fish species available, are all factors that will influence the catch rates of differently hung nets, therefore the results shown can not be taken as an overall statement for catching efficiencies of nets with different hanging ratio, but rather as an indication of catching possibilities of certain species with specific gear construction in a given area.

The height of driftnets is regarded to be a factor of greater importance for the fishing efficiency than the length of the single nets. It should be carefully considered in view of the migrating behaviour of the fish. For surface migrating fish, like salmon, the nets can be made shallower than for other pelagic fish, like for instance herring and sardines. Also, when the fish are concentrated in shallow layers, the nets can be made shallower than when they are more scattered in depth. The rigging of driftnets and the fishing tactics have to be considered when deciding the height of the nets. If the nets can easily be depth-regulated when shooting on the basis of fish detection and location (by means of echo sounders), the requirement to have higher nets is less than if they had to be set without any knowledge of the fish distribution. Bottom driftnets usually have a low height compared to midwater and surface driftnets. The reason is that most demersal species remain close to the bottom, and that high bottom driftnets would be more exposed to damage in shallow waters, where they are most commonly used. Other factors that account for the reduced heights of driftnets are the cost and handling effort which are both increased with higher nets. The number and size of driftnets for small-scale fisheries are normally restricted by the cost, handling and space facilities of the vessels. As can be seen from Table 9, commercial midwater and surface driftnets have heights between 7 m and 15 m, while shrimp bottom driftnets are only 2 m high.

Table 9

Type of driftnet	Height of netting	
	No. of meshes	Metres (Stretch Height)
Shrimp	50	2
Herring	150-200	7.5-10
Salmon	50-120	8-16
Tuna	50-100	12-15

The theoretical hung height (D) of a net with a given hanging ratio (E) will be:

$$D = N. Lm.$$

E is the horizontal hanging ratio, where N is number of meshes deep, and Lm is the mesh size. Figure 13 shows a graph from which the theoretical height relative to the stretched height of the netting, as a function of the horizontal hanging ratio, can be calculated.

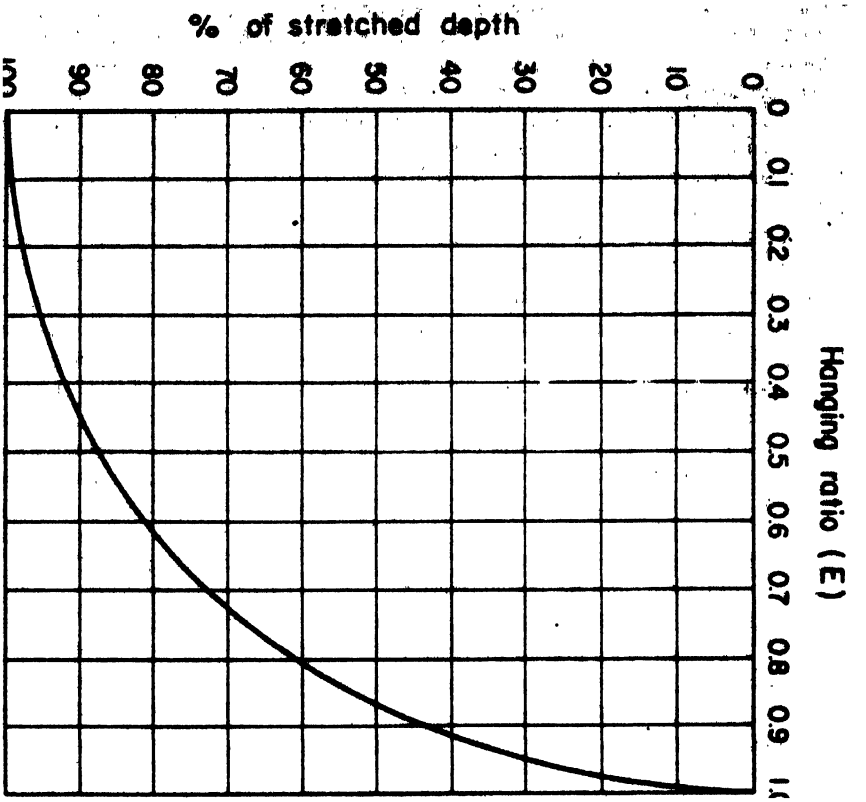


Fig. 13 Relation between hung depth of netting and horizontal hanging ratio

The real height of a driftnet when fishing, however, is dependent on not only how well the net is stretched, but will be somewhere in between the theoretical depth and the stretched depth (N L), and might to some extent be influenced by currents and wind (usually reduced).

Also, the side edges of the netting in driftnets should be hung onto the gavel lines. The purpose of the gavel lines is both to increase the entangling property of the net by slack hanging to the gavel lines and to strengthen the edge of the net. On the other hand the vertical hanging coefficient may be correspond to the theoretical height of the netting (see Figure 13) or, as in some cases, made larger, by hanging the gavel lines to fully stretched netting.

2.1.8 Reinforcing of the netting (selvedges)

The netting of the driftnets may be reinforced along the floatlines and leadlines, and even along the gavel lines. The purpose of the reinforcing or selvedge is to strengthen the netting where it will have the greatest strain or chafing due to the attachment to the framelines. The selvedge also makes mending easier, as when the net tears it will tear along the joint between the netting and the selvedge, and the repair will not involve rehanging of the net. The selvedge therefore has a

stronger twine than the bulk of the netting or the meshes can be doubled to achieve the same effect. Often the mesh size also is larger, in which case it is usually a multiple of the mesh size in the body of the net. The height of the selvedge may range from half a mesh (one row) to several meshes. In the case of selvedge several meshes wide, the twine size may be increased successively from the main netting to the hanging line. Generally, there will be equal selvedges to the floatline and leadline.

The need for and use of selvedges varies with the type of fishery. In bottom driftnets the need for selvedges is greater because of increased wear on the netting. An example is the 36-mm Indian bottom shrimp net with very fine twine (R 50 tex), which has a one and a half meshes (3 rows) of 50-mm mesh selvedge in R 160 tex. Another example is a driftnet for Spanish mackerel which has a 25-mesh wide selvedge of R 550 tex at the bottom, while the main netting has R 400 tex. An extreme example of guarding is the Japanese salmon net where six rows of the selvedge have different twine sizes, increasing in thickness from R 272 tex to R 1 076 tex at the frameline.

2.2 Floatline

The floatline of a driftnet has several functions. First of all it must be strong enough to withstand the hauling forces (together with the leadline). Additionally, it is sometimes used both as a hanging line for the netting and as an attachment line for the floats. It is highly desirable that a floatline have a good length and twist stability. It is therefore normal practice in the preparation of driftnets to stretch and take out any excess twist of the floatline and leadline ropes before the net is mounted to them. (Note: this is not required if braided rope is used).

Similar to the materials for the netting, the floatlines of the driftnets nowadays are mostly made of synthetic materials, and all the main types of these may be used. The advantage of polypropylene (PP) and polyethylene (PE) ropes is that they are buoyant and thereby have some floating capacity. Heavy materials such as polyester (PES) and polyvinyl alcohol (PVA) are for this reason not as suitable, but both have the advantage of being less elastic. Although used quite a lot, polyamide (PA) is not an ideal material for floatlines due to its elasticity. Of the natural textile materials, both sisal and manila have good properties as floatline ropes.

With respect to the type of fibre, to be used in floatline ropes, it should be mentioned that staple fibre gives a rough surface to the rope, making it easy to grip and handle and favourable to tie knots onto. Also, split fibres have suitable properties for floatline ropes and are often used.

The construction of the floatline rope should also be considered. If the nets are exposed to high loads during hauling, braided ropes would be an advantage compared to twisted ropes because they will not twist so easily under tension. Another way of counteracting the twisting problem is to use two similar twisted ropes, but with opposite direction of twist (S and Z lay).

The thickness of the floatline in driftnets for small-scale fisheries can vary from about 3 mm to more than 15 mm in diameter. When two (similar) ropes are used, the maximum thickness of each will be about 8 mm. The most important criteria for the minimum thickness of rope is the strain when hauling, which is dependent on a number of factors such as:

- rigging method
- number of nets in the fleet
- expected weight of the catch
- fishing depth
- current and weather condition
- hauling speed
- size of the vessel

On the other hand, often handling considerations such as the hand or winch grip and stowing necessities, may be the reason for choosing thicker floatlines than necessary for the strength. The size of the fish seems to have minor influence on the thickness of the actual floatline (and leadline) used in some commercial driftnets, as demonstrated in Table 10.

Table 10

Net type	Country	Floatline Mat	Floatline No.	Floatline Dia.(mm)	Leadline Mat	Leadline No.	Leadline Dia.(mm)
Shrimp	India	PE	1	3	Cot	1	8
Herring	Japan	PP	1	8-10	PP	2	8-10 (4-5 ea
Herring	France	PA	2	5-6(2.5-3 ea)	Leadrope		4-5
Span. mack.	Thailand	PVA	2	5			
Salmon	USA	PE	1	9-12	PES		
Salmon	Germany	PP	1	6	No leadline		
Salmon	Japan	PP	2	5 (2.5 ea)	PP	2	12 (6 ea)
Large mesh	Sri Lanka	PVA	1	8-10	PVA	1	8-10
Large mesh	Bangladesh	PA	1	8	Jute	1	8-12
Shark	Australia	PP	1	16	PP	1	8
Bluefin	France	PA	1	8	PA	1	8

"Floatropes" - ropes with small floats braided in as a core, which also are actually used as (part of the) floatline on driftnets, are dealt with in chapter 2.4.

2.3 Leadline

The same considerations with respect to use and properties that have been made for the floatline are also valid for the leadline. However, with respect to the type of material it may be advantageous to use heavier material as, for instance, PES and PVA in the leadline for the purpose of gaining extra weight. With respect to dimensions of the leadline, the same factors should be considered as is listed in chapter 2.2 for the floatline. On midwater and surface driftnets there is no reason for using thicker leadline than floatline, and often the opposite is the case as shown in Table 10. On the Indian bottom shrimp driftnet, however, the leadline is thicker, illustrating common practice in bottom set nets.

Similar to the floatfope mentioned above, there is also commercially available for driftnet purposes a leaded rope, a rope with braided or twisted in lead core (see chapter 2.5).

2.4 Floats

The purpose of the floats on a driftnet is to achieve the "right" buoyancy to the floatline, including both requirements for the total buoyancy and its distribution along the line. It is also important that the floats do not entangle in the netting and are otherwise easy to handle. The third requirement for the floats is that they are strong enough to withstand heavy pressure in deep waters when so required, and that they do not absorb water.

In principle, there are three types of flotation, namely:

- floats fastened directly to the floatline or threaded on to it
- floats fastened to the floatline by means of strops
- use of floatline with integrated flotation

Very often two of the three types may be combined.

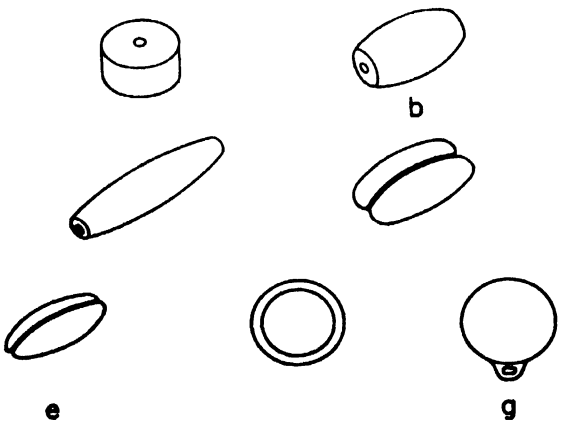


Fig. 14 Different types of floats on driftnets

In the case of solid floats attached to the floatline pieces of wood, cork, plastic or any other buoyant material can be used. As with other components of driftnets, synthetic materials are dominant today, and a great variety of different shaped and different sized plastic floats are in use. The most common shaped floats (see Figure 14) are cylindrical (a), egg-shaped (b), and cigar-shaped (c) - all with centre-hole; and flat longitudinal (d), and egg-shaped (e) floats with grooves. The ring float (f) and ball float (g) are not commonly used on driftnets.

Modern plastic floats have a density (P_m) of about 0.15 g/cm³. The net buoyancy of the float (B) therefore can be calculated on the basis of the volume (V) of the solid material according to: $B = V(P_{sw} - P_m)$ where P_{sw} is the seawater density and P_m density of modern plastic floats.

Table 11

Form	Dia. (mm)	Length (mm)	Centre hole dia. (mm)	Net buoyancy (g)
Cylindrical	30	50	6	30
	50	30	8	50
	65	20	8	55
	70	30	12	95
	80	30	12	131
	80	75	12	330
	100	90	14	614
	125	100	19	060
	150	100	25	523
Eggform	45	76	8	70
	51	89	8	100
	57	102	10	160
	89	140	16	560
Cigar-form	46	158	8	180

Table 11 gives the net buoyancies for some common shapes and dimensions of driftnet floats from a Norwegian supplier (expanded PVC), all with centre hole.

As an example of the formula, we take the first figure from the Table of a cylindrical shaped float of 30 mm (3 cm) diameter, $\emptyset_1$, 50 mm (5 cm) length and central hole of 6 mm (.6 cm) diameter, $\emptyset_2$; thus:

$$V = \frac{\pi}{4} (\emptyset_1^2 - \emptyset_2^2) \times 1$$

$$V = \frac{3.14}{4} (3^2 - 0.6^2) \times 5 = 33.9$$

$$B = V(P_{sw} - P_m)$$

$$B = V\ (1.02 - 0.15) = 33.9\ (0.87) = 29.5 \text{ g buoyancy}$$

The size of floats varies with the type of nets and the fishing conditions, and in small scale fisheries, the net buoyancy of single floats on driftnets is in the range of 50 to 200 g. The advantage of using a smaller size and consequently a larger number of floats to obtain the necessary buoyancy is a better shape of net and easier handling procedure. However, the floats should be larger (lengthwise) than the stretched mesh size of the net to prevent them from going through the meshes, as this can cause the net to tear and the work clearing the entangled floats is time consuming. Another disadvantage of many small floats is that they will be more expensive and more laborious to mount to the net than a few larger floats.

The advantage of the grooved floats is that they are easier to replace, but they also become loose more easily.

Floats fastened by strops are easier to change according to the demands for buoyancy and depth regulation of the net. To achieve this, a wide range of alternatives can be used including floats not particularly made for driftnets. For instance, various types of airfilled plastic cans may be used. These floats are larger and therefore more widely spaced. Several mixtures of synthetic materials are used today by numerous manufacturers to make floats for fishing gear, and the shape, density, colour and quality vary quite a lot. When deciding on types of floats for midwater or bottom driftnets it should be borne in mind that the given depth rating is usually close to maximum. Therefore it is advisable to use floats with say 30% higher depth rating than the maximum intended use, bearing also in mind that the water pressure increases by approximately 1 kg per 1 cm^2 at every 10 m depth increase.

The floatrope with braided-in buoyant pieces is almost as smooth as a normal rope. It is therefore preferable in view of handling and entangling problems. The buoyancy will also be more evenly distributed with such a floatline, having positive effects on the shape of the nets and thereby the catching efficiency.

2.5 Sinkers

A variety of types and sizes of weight are used for sinkers on driftnets. Similar to floatlines, there are three types of sinkers according to how they are mounted on the leadline, namely:

- Sinkers mounted directly on the leadline,
- Sinkers mounted on the leadline by means of strops,
- Leadline with braided-in or twisted-in lead cores.

It is necessary that sinkers fastened to the leadline are smooth so as not to become foul of, or entangled in the netting. One popular type is the cigar-shaped or egg-shaped lead piece which is thread onto the leadrope (see Fig. 15 (a)). One disadvantage with this type of sinker is that it cannot be removed easily or replaced. For this reason, the open lead ring that is diametrically bent round the leadrope (Fig. 15 (b)) is an alternative. The opening of the ring must be carefully fitted and closed so the net does not snag on it. Smooth and carefully selected stones or clay stones held in pieces of small mesh netting may be attached as sinkers directly to the leadline.

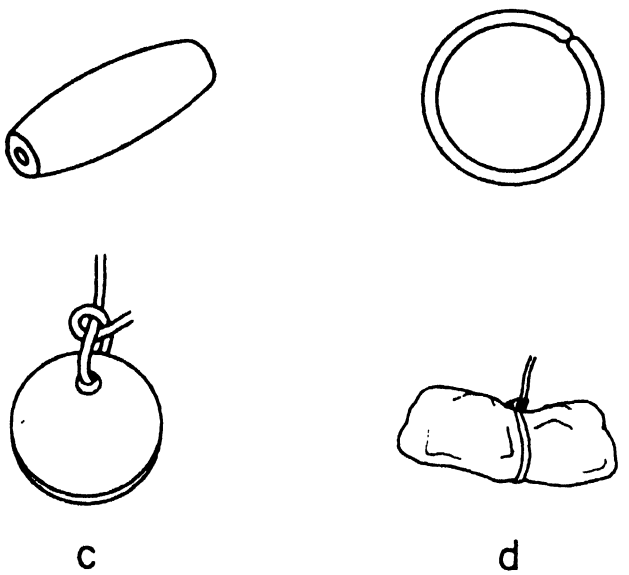


Fig. 15 Different types of sinkers

For sinkers fastened to leadline by means of strops, several types of heavy material as iron pieces, rock, clay, brick and cement stones can be used. Because the strops allow for the sinkers to be separated from the net when handling onboard, their smoothness is not so critical, but they should not have surfaces which will catch easily in the netting. Some different shapes of the stone sinkers and the way they can be attached are shown in Figure 15.

The leaded rope, or leadrope, is a fairly new development that has become very popular in some driftnet fisheries. There are two types of leadrope. One for thinner lines where a central lead core is braided into the rope, the other for thicker lines twisted rope with a lead core in each strand of the rope. The surface of the leaded rope is as smooth as a normal rope thereby giving easy handling and reduced entangling problems when shooting.

Table 12

Leaded ropes braided or twisted commonly used for driftnets

	Dia. (mm)	Weight (g/m)	Breaking strength (kg)
Braided, centre core (PA)	2	23	73
"	3	71	100
"	4	123	200
"	5	152	300
Twisted, 3-strand (PP)	6	87	495
"	7	112	675
"	8	133	865
"	10	216	1 280
"	12	266	1 825
"	14	330	2 510

In Table 12, some examples of size, weight and breaking strength of leaded ropes for all nets are given.

3. FISHING OPERATIONS

3.1 Vessel Layout and Deck Equipment

The requirement of vessel and deck equipment for driftnet fishing is very dependent on the scale of the fishery. One of the advantages of driftnetting is that in a small-scale form, it can be undertaken without a high cost. In fact, for surface driftnetting with a few nets, a small one-man boat with no extra equipment is sufficient. The only requirement is a storage bin for the nets with a smooth edge or rail for the nets to slide over when shooting. The hauling can easily be done by hand, and all that is required is space for the man to haul either in the stern, or near the stem of the boat.

However, more industrialized driftnetting requires some further refinements to the vessel and equipment. First of all, there should be some kind of hauling device. There are a large variety of different types of haulers that can be fitted on motorized vessels. They can be classified in two groups, according to whether they are railmounted or deckmounted.

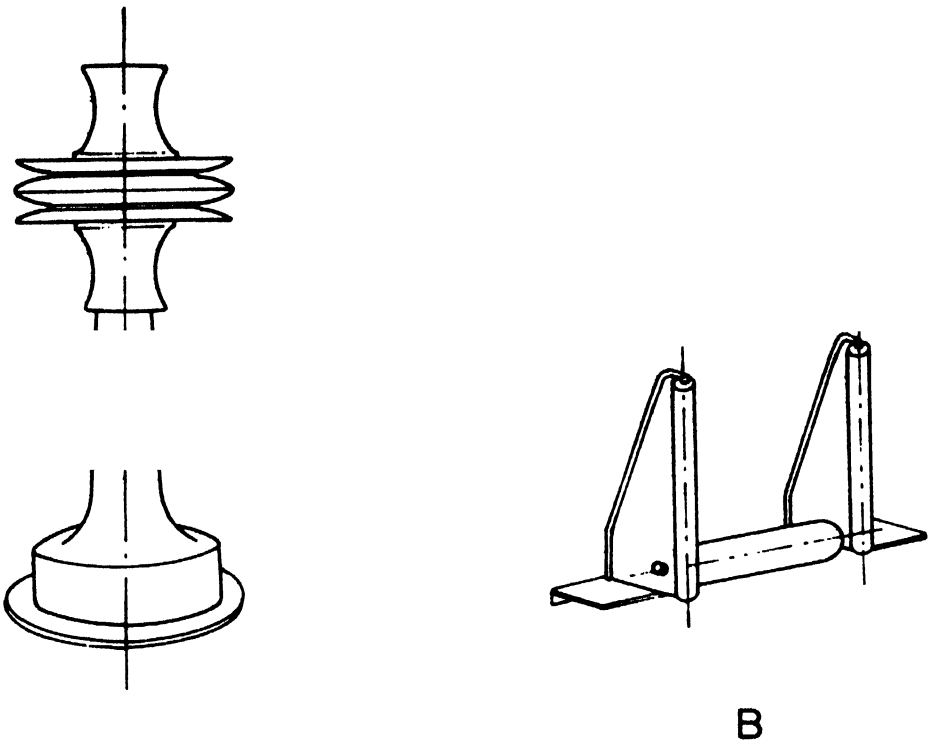


Fig. 16 Deck-mounted hauler and rail roller

Figure 16 shows a hydraulically-powered vertical deckmounted hauler with horizontal-mounted double-hauling sheaves - the traditional hauler in north European driftnet fisheries. The deckmounted hauler requires a rail roller, of which an example is shown in Figure 16 (b). Figure 17 shows the typical deck layout of a small gillnetter with such equipment. To simplify the work of releasing the fish from the nets, the vessel is equipped with a platform on which the nets are pulled from the rail roller to the net storage aft.

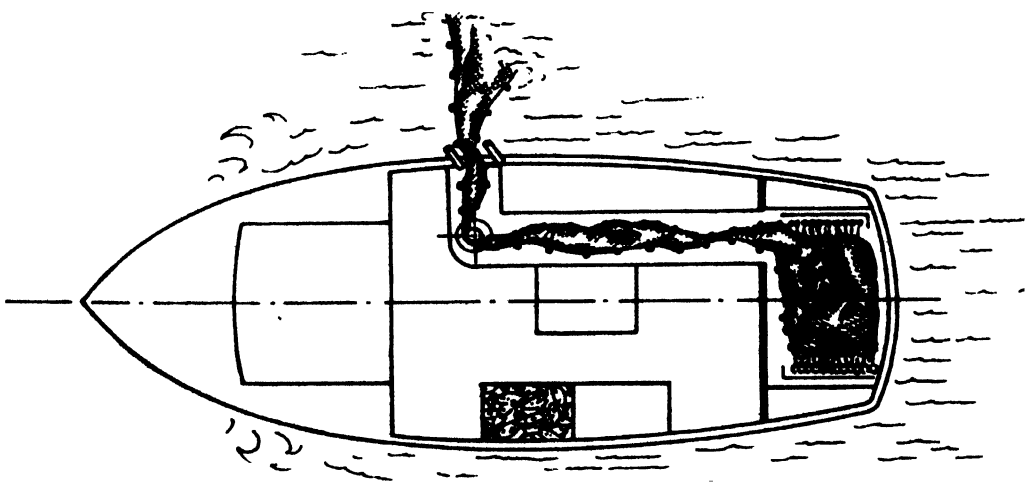


Fig. 17 Deck layout of driftnetter

Many different types of hydraulic powered rail-mounted haulers have been developed for small-scale net fisheries, of which an example is shown in Figure 18.

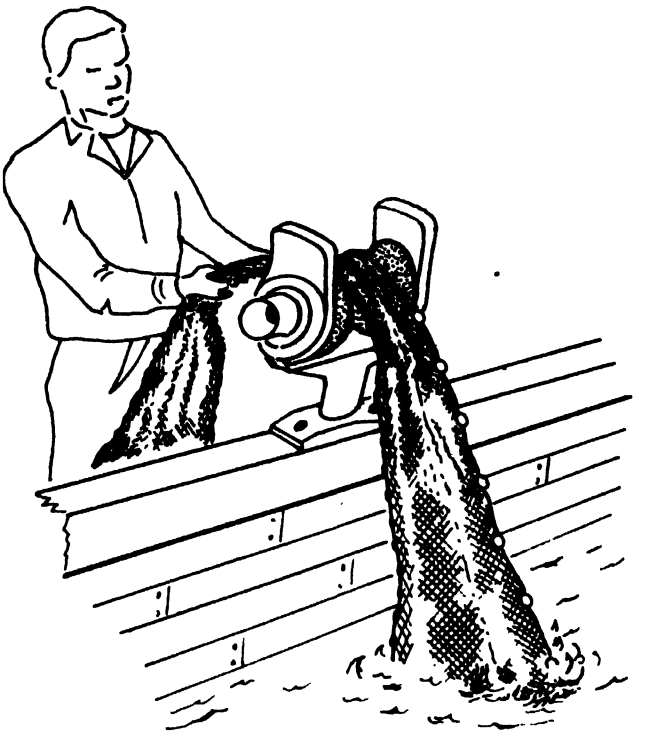


Fig. 18 Rail-mounted hauler

Net drums can be used to retrieve and store the driftnets. A stern-mounted drum is shown in Figure 19. Drums are especially suited for nets with a large hanging ratio, and for monofilament nets that otherwise may be difficult to handle and store onboard. The disadvantage of a net drum on a relatively small boat is in clearing the catch from the nets, while hauling, and in connection with removing of a single net from the fleet, i.e. for mending, etc.

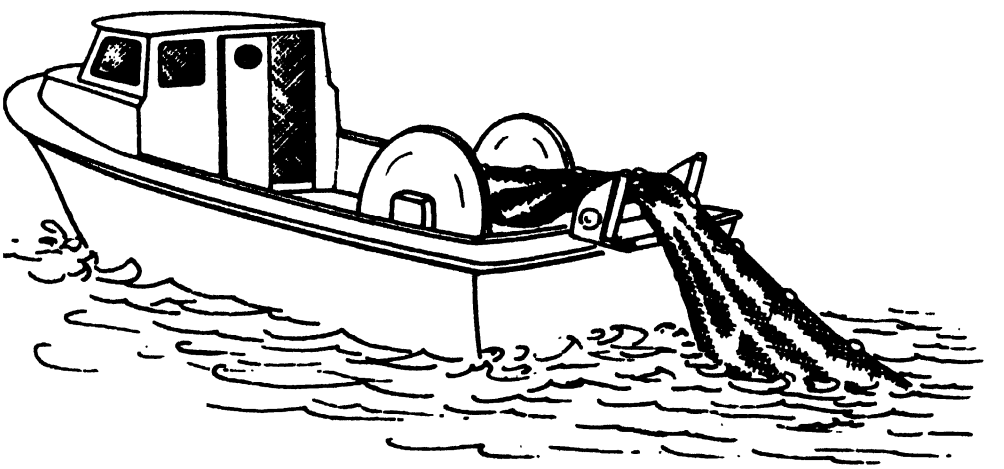


Fig. 19 Driftnetter with drum

3.2 Techniques and Method of Shooting

The technique and method of shooting driftnets includes consideration of several factors that are of importance for the fishing result, such as:

- Area and location (fishing ground)
- Time for shooting
- Depth of the nets
- Number of nets in the fleet
- Position and direction of shooting
- Fishing time

The decisions are not only influenced by how the highest catch per net can be obtained, but also how to prevent entangling problems and damage of the nets and fish.

3.2.1 Fishing ground

In fishing regions where several fishing grounds are suitable for driftnetting, the choice of where to go and set the nets is very important for the fishing result.

Factors which have to be considered when deciding the fishing ground or location for shooting are:

- The knowledge of the fish resources and migration
- Weather and current conditions
- Presence of other driftnetters
- Other ship movements

Consideration of the fish resource and migration should include the presence of fish, i.e., visual or acoustic detection and also its behaviour. The knowledge of these factors is usually based on earlier experience and information obtained from other fishermen fishing in similar areas, or one's own observation of fish presence and behaviour when fishing with different gear.

Current and weather conditions are important factors to consider in the choice of one of several fishing grounds. If the weather is bad, sheltered grounds may be possible to fish, even for small driftnetters, while on more exposed grounds it would be impossible and/or unsafe. Strong current may hamper the fishing with driftnets because the nets can become distorted and there are risks of entangling with other fleets of nets. Another consideration associated with weather condition is how it influences the behaviour of fish and thereby the fishing efficiency. If the weather is too bad the fish may go deeper and thereby outside the depth range of the nets. This is especially a problem for typical surface driftnetting, (e.g. salmon) and the effect is well known in the Norwegian fishery. Another significant problem in the same fishery is associated with very good weather. If there is no wind and/or waves rippling the surface, the fishing efficiency is very poor, probably because the salmon observe the nets more easily and thereby avoid them.

The effects of other driftnetters may also be both negative and positive. The negative effect arises because of the competition over the best setting positions and the risk that the fleets of nets entangle with others. The positive effects can be the useful information obtained from other driftnetters about the presence of fish and its behaviour.

The risk of other vessels crossing the fishing grounds may seriously affect the fishery, because the nets or the net buoys are so exposed to damage by the ships. Information about such traffic should therefore be seriously considered both when deciding the fishing ground and the shooting position within the ground.

3.2.2 Time for shooting

The time for shooting is of particular importance for driftnetting because of the short fishing period normally anticipated. This is due to the quick spoilage of the fish after death, especially in tropical waters and the usual daily vertical migration of pelagic fish.

The nets should therefore be fished during the best fishing period of the day or night. Generally, driftnets like other set nets have their best catching efficiency during night because the nets are then less visible to the fish. For this reason the best shooting time is in the evening just before darkness. Another important factor is the migrating movement of the fish at dusk and dawn. This is of special importance for species that may change depth as a result of changing of light. In this respect plankton feeders, such as herring, which are following the plankton to the surface, would be fished near the surface during the evening and early morning.

The amount of illumination is of great importance, and the "moon effect" is demonstrated by the fact that in several driftnet fisheries catches tend to be poorer in bright moonlight.

In fisheries where the day and night effect is not valid, like in the northern Norwegian summer driftnet fishery for salmon, the nets are also worked successfully during daytime.

3.2.3 Depth of the nets

The decision on the right depth of midwater driftnets is very important for the catch rate, especially when fishing in deep water and under variable fishing conditions. Experience and knowledge of the behaviour of the fish is of great importance. Variable environmental conditions such as water temperature, thermocline, current, weather and light conditions have to be considered also. Because of variations of different species and conditions from place to place, general information concerning

this problem is of little value. However, one general rule would be to set the nets deeper than normal, both in bright daylight and under bad weather conditions. It can also be stated that by increasing the depth (height) of the nets used, the problem of placing them at the right depth in the water column becomes less, but this would in most cases be doubtful advice due to the increased handling problems and extra cost.

3.2.4 Number of nets in the fleet

The length of the fleet of driftnets is an important decision to be made before or when shooting. Important factors for the choice are the fish distribution, fishing ground availability and weather/current conditions.

If the fish are evenly distributed, or their concentrations are uncertain, it is advisable to shoot as many nets as possible. On the other hand, if the fish are concentrated in a well defined area, it is better to shoot fewer nets, which then can be set more optimally. Also, if the fishing ground is densely occupied by other fleets of nets, it may be preferable or necessary to reduce the number of nets in the fleet. The reduction of the number of nets in the fleet is also important if the weather and/or the current conditions are unfavourable.

3.2.5 Position for and direction of shooting

Both the actual position and the direction of shooting driftnets is of great importance for the fishing efficiency. The reason is that successful catch rates depend on the fact that driftnets, like other set nets, are positioned in and perpendicular to the path of the fish. This is easier when fishing for species which have a recognized migrating route, like for instance salmon or hilsa when migrating to the spawning river, than in fishing on a spawning or feeding grounds. In the northern driftnet fisheries the consequence of the adaptation to the migrating routes for different species is that salmon driftnets are usually set perpendicular to the coast, while mackerel nets in the same areas are set along the coast. The explanation is that salmon are migrating along the coast to their particular river to spawn, while mackerel are migrating from further offshore into the coastal waters in the summer.

The ideal shooting position and direction of driftnets may often be altered or hampered due to weather, current and other fleets of nets.

In strong wind the nets are mainly set down wind or with the wind, especially if the vessel remains connected to the nets when fishing. In strong current and where applicable, the setting position should be so planned that the nets will have the longest drift in the best known concentrations of fish. The wind current factor (vessel drifting mainly by the wind, but the nets by the

current) must be carefully considered and it should be ensured that the nets are not drifting into rocks or other shallow grounds, that may lead to damage or loss of the nets, and even danger for the vessel and crew. Also, the risk of drifting into other fleets of nets must be considered when deciding the setting position. As a general rule when considering the effect of the current on the catching possibilities of the drifting nets, it should be borne in mind that no migrating fish generally swim against the current; therefore, whenever possible, the shooting of the nets should be across the current.

3.2.6 Fishing time (soaking time)

The drifting time of each setting varies a great deal from one fishery to another and even within the same fishery. In tropical countries where sea temperature is high and different fish species are caught in one set, it is advisable to haul the nets after 4-5 hours maximum soaking. The same is true in fisheries where large catches are expected in crowded areas, where fish are known to be migrating quickly either vertically or horizontally, and where other fish, like sharks, will feed on those fish species caught in the nets. In driftnet fisheries for large pelagic fish offshore much longer soaking time is practiced, often from dawn to dusk. This, of course, reflects the fact that large species are stronger and live longer after being caught in the nets.

3.3 Shooting

Shooting of driftnets is a fairly simple operation compared to shooting of other types of fishing gear. The nets are shot from a shooting position at the stern or at one side of the vessel. It is best if the shooting can be arranged from the stern. The nets are cleared up and stored with the leadline and sinkers to one side and floatline, buoys and buoylines to the other. The rail of the vessel must be smooth with no rough edges or projections, so the nets can slide out at the speed of the boat. The buoys and possibly the sinkers should preferably be thrown manually to either side of the net to avoid entangling.

If the rail is not smooth or, for other reasons, there may be problems due to fastening or entangling of the nets, the nets should be shot manually. This is very common when, for instance, rowing boats, are used.

On driftnetters with netdrums, the nets are usually shot directly from the drum.

The shooting speed of driftnets is not a critical factor and can vary from one up to about eight knots, or more, but as a general rule, the nets should not be allowed to run out faster than the vessel is moving, unless the nets are meant to catch the fish by entagling rather than gilling.

3.4 Hauling

Hauling can be done either from the bow, side or even the stern of the vessel. Hauling from the stern is normally practiced by very small boats only and is difficult if the weather is not good. When hauling from the side or bow the vessel can head into the wind , making it easier for the crew to work the nets, and preventing losing of catches by reducing the strain on the nets. Hauling speed may vary both with the hauling equipment and fishing and weather conditions. If the fleet contains only few nets, they can be hauled in bulk and the fish released afterwards. Preferably, the fish should always be released when hauling. This will both reduce the total handling effort and not least improve the quality of the fish. If there is enough crew, the nets should preferably be cleared out and stored in the shooting position during hauling.

4. CALCULATION OF MATERIALS NEEDED FOR CONSTRUCTION OF DRIFTNETS

As driftnets for the different species vary quite a lot due to the difference in size (and behaviour) of the species, an example of calculation for a herring driftnet will be demonstrated.

4.1 Netting

The netting is of multifilament polyamide (PA nylon) twine. The reason that monofilament is not chosen is that the visibility is not regarded to be a critical factor in nets for herring and other clupeids. The multifilament is also easier to handle onboard and has less tendency to tangle. Knotless netting, which could have been a cheaper alternative, is rejected because of less availability and problems with mending. Multimono-filament could also be considered, but is not normally used for small species like herring.

The twine thickness is set to 210/6, which indicates the twine size in deniers which is the weight in grammes of 9000 m of twine. 210 is the weight per 9000 m of the filament, and 6 is the number of filaments.

The size in denier of the twine 210/6 is in fact 210 x 6 = 1260 denier, or 1260 gr for 9000 m, corresponding to about R 150 tex. This is a medium twine thickness for clupeid driftnets which should combine a good fishing efficiency and sufficient strength.

For this exercise, the mesh size chosen for the herring driftnet is 55 mm. This is a relatively small mesh size for adult herring, but it will ensure that a large percentage of the herring is not wedged with the problem that may involve release from the net and damage to the soft skin and flesh of the fish.

The dimension of the driftnet is set to 200 meshes height and 1200 meshes long. The height of 200 meshes, giving a stretched height of 11 m, should ensure a good vertical coverage. The 1200 number of meshes in length allows for a suffficient hung length of the driftnet, making it practical to join it to other fleet of nets.

The hanging ratio is set to 0.65. This ensures a relatively good stretching of the meshes in the net, which is optimal for clupeid fishery where entangling is not desired.

Calculation of the main dimensions of the net:

No. of meshes long: $N_1 = 1200$
No. of meshes high: $N_2 = 200$
Meshsize: $L_m = 55$ mm
Hanging ratio: $E = 0.65$
Hung length: $L = N_1 . L_m . E = 200 \times 0.055 \times 0.65 = 42.9$m
Theoretical height: $D = N_2 . L_m \sqrt{1 - (0.65)^2} = 200 \times 0.055 \times = 8.36$ mm

4.2 Framelines

To allow for joining to other nets or to connecting cables, the float and leadline ropes should be extended about 80 cm at each side of the netting. The total length of the framelines will therefore be:

$L = 42.9 + (2 \times 0.8) = \underline{44.5 \text{ m}}$

The diameter of the framelines should be strong enough to allow for hauling of large catches that may occur in clupeid fisheries, and they should be thick enough to ensure a good grip in the sheave of the hauling winch.

For the floatline, two ropes of the same material and dimension are used, but with opposite direction of twist. Polypropylene staple fibre is chosen because it has a good grip, it does not stretch a lot, and it is also a cheap material. The thickness of each rope recommended is 6 mm, giving a total breaking strength of the floatline of approximately 1 100 kg.

For the leadline, a 4 mm braided leaded rope is chosen. According to Table 12, the breaking strength of such a rope is about 200 kg.

The net should also be fitted with gavel lines, vertical framelines at each edge of the driftnet. The purpose of the gavel lines in herring driftnets is to strengthen the net and to make it easier to handle. The length of the gavel lines (L_G) may be the same as the stretched height of the netting or shorter to match the theoretical height. For gavel lines, 3 mm (dia.) PA rope is used. The net is stretched along and each mesh tied to the rope giving a length of:

$L_G = N_2 . L_m \quad 200 \times 0.055 = 11$ m

4.3 Floats and Sinkers (Buoyancy and Ballast Calculations)

The basis for the buoyancy and ballast calculations is that the net shall be fished below surface (midwater rigging), requiring a slight negative buoyancy. Before the necessary capacity of the floats and the sinkers is decided, the weight in sea water of all the other net components has to be calculated:

4.3.1 Netting

Length of twine in the netting $2N_2 \times (N_1 \times L_m)$ in m

Weight of twine (without knots)

$$\frac{2N_2 \times (N_1 \times Lm) \times 210 \times 6}{9\,000} \text{ in g}$$

Weight of twine with knots
Knot factor, in relation with mesh and twine size for the weight including knot. Considering mesh size L_m = 0.055 and twine 210/6, the appropriate knot factor equal to K = 1.1

Thus, weight of the net in air W_N is:

$$\frac{2xN_2 \times (N_1 \times L_m) \times K \times Den \times 10^{-3}}{9\,000} \text{ in Kg}$$

$$\frac{2 \times 200 \times 1200 \times 0.055 \times 1.1 \times 210 \times 6 \times 10^{-3}}{9\,000} = 4.06 \text{ Kg}$$

Weight of the net in sea water, W_{Nsw}

$W_{Nsw} = W_N (1 - P_{sw}/P_{pa})$

where P_{pa} is Polyamide specific mass (kg/m³)

$W_{Nsw} = 4.06(1 - 1025/1140) = \underline{0.41 \text{ kg}}$

4.3.2 Floatlines (remember the floatline is made of two PP 6mm)

Weight in air W_F

$W_F = 2 \times L \times 0^2/4 \times \pi \times P_{pp}$

where P_{pp} is Polypropylene Specific Mass (kg/m³)

$W_F = 2 \times 44.5 \times (0.006)^2/4 \times 3.14 \times 910$

Weight in the Sea Water W_{Fsw}

$W_{Fsw} = W_F (1 - P_{sw}/P_{pp})$

$= 2.29 (1 - 1025/910) = 0.29$ Kg

- Gavel lines

Weight in air W_G

$$W = 2 \times L_G \times \emptyset^2/4 \times \pi \times P_{pa}$$

$$W_G = 2 \times 11 \times (0.003)^2/4 \times 3.14 \times 1140* = 0.18 \text{ kg}$$

* gavel lines are in Polyamide, Specific Mass P_{pa} is 1140

Weight in the Sea Water W_{Gsw}

$$W_{Gsw} = 0.18 (1 - 1025/1140) = 0.02 \text{ Kg}$$

4.3.3 Leaded rope

The vertical stretching of the netting is decided by the weighting of the leadline. This is given in weight per length of the net, and will, for a chosen leaded rope, be the weight of the leaded rope in air minus the buoyancy of the rope. From the leaded rope table it is found that the 4 mm leaded rope has a weight in air of 123 g/m.

$$W_L = \text{g/m} \times \text{length}$$

Total weight in air $W_L = 0.123 \times 44.5 = 5.47$ kg

The buoyant force B_L due to the thickness of the rope is:

$$B_L = 44.5 \times (0.004)^2/4 \times 3.14 \times 1025* = 0.58 \text{ kg}$$

* 1025 is the Specific Mass of Sea Water displaced

Weight in the Sea Water W_{Lsw}

$$W_{Lsw} = W_L - B_L = 5.47 - 0.58 = 4.89 \text{ kg}$$

It should be noted that the weight in water is a function of the density of the water. It will therefore be heavier in fresh water and not so heavy in salty water, i.e. Black Sea. In this case, the standard sea water has been calculated.

The weight of the leaded rope in the sea water, nearly 110 g/m is an acceptable weight for a herring driftnet, but depending on the fishing conditions, both lower and higher values can be used. If the fishing goes on under conditions with steady wind and waves, the weight should be increased to as much as 120 g/m.

If leaded rope is not used (because it is not available or it is too expensive) the alternative should be to use hollow lead pieces or lead rings on the leadline.

When using such discrete distributed sinkers, it is better for the fishing efficiency to use many small sinkers than a few large ones.

On the basis of the desired weight per metre (wl) and the weight of each sinker (w), the space intervals of the sinkers (ls) can be calculated according to:

ls = w/wl

As an example for the desired weighting of the herring driftnet of 110 g/m with 75 g sinkers, the sinkers should be placed at intervals of 68 cm(i.e., 75/110 = 0.68 m).

4.3.4 Appropriate Floatation

A proper ballasting is obtained with little extra weight of the leadline compared to the floatation.

If the weight of the leadline in the sea water is according to our calculations round 110 g/m the float capacity, i.e. the net buoyancy of the floats, should be 100 g/m.

0.1 x 44.5 = 4.45 kg

This will give a total net sinking force for the net of:

Weight in water of (netting + floatline + gavels + leaded rope + floats) = Total weight in water.

Note that floating material is minus weight.

0.41 - 0.29 + 0.02 + 4.89 - 4.45 = 0.58 kg

allowing it to stretch the buoy strops sufficiently. According to Table 11, several float alternatives exist. However, a cylindrical float 70 x 30 mm with a net buoyancy of 95 g is chosen. It has a relatively large diameter to ensure that it will not entangle with the meshes. The spacing of the floats to obtain the right buoyancy will be:

95 g/100 g/m = 0.95 m

5. CONSTRUCTION OF A FLEET OF MIDWATER DRIFTNETS FOR CLUPEIDS

A fleet of driftnets for clupeids can contain from 2 to more than 30 nets even in small-scale fisheries. The actual number of nets must be chosen according to a number of factors depending on the actual situation, such as:

- size of vessel,
- number and skill of the crew,
- weather and current conditions,
- concentrations of fish,
- presence of other boats and fleets of nets,
- cost and availability of the nets or net materials.

However, the calculation and preparation of a single net does not depend much on the actual number of nets chosen, except for the length of the framelines which could be increased for a longer fleet of nets. As a guidance, the actual description in chapters 3 to 5 is from a fishery with about 20 nets in the fleet, giving a fleet length of about 860 m.

5.1 Preparing the Netting

The netting for a fleet of driftnets for clupeids may either be of knotted or knotless type. In some herring driftnet fisheries knotless netting is more popular and is used by a lot of fishermen. The main reason for its popularity is that it is cheaper than knotted netting.

Netting for driftnets can be prepared differently, but hand-braided nets will always be knotted, and braided to the chosen number of meshes required both in depth and length.

A machine-made sheet of knotted netting for clupeids normally is less than 500 meshes wide, limited by the number of shuttles in the machine, and as most clupeid driftnets generally are longer (600-1500 meshes) it is therefore advisable to orient the limited number in width of the machine (N-direction) to the depth of the driftnet. By this netting for two or three nets (in height) can be braided simultaneously, each being, for instance, 150 meshes deep, on 300 and 450 shuttle machines, respectively.

One advantage of this method is that the selvedge meshes can be braided together with the rest of the webbing, simply by supplying the edge shuttles with heavier twine. If more than one net (in depth) is required, one shuttle between the nets can be left without a twine to split the netting.

How long each netting sheet can be made depends on several factors, such as the size of the shuttles, mesh size and twine thickness. Generally, the netting sheets are made so long that several nets can be cut from it (in length).

5.1.1 Example of netting planning

A sheet of netting made from a 400-shuttle machine that is made 3 600 meshes long can be cut into six 200-mesh deep nets if each net is made 1 200 meshes long. If the number of nets in the fleet is planned to be 30, five netting sheets of this size must be provided.

5.2 Hanging and Mounting the Netting

The next step in the preparation of the driftnets after cutting the netting is to mount the netting on the hanging lines, with the chosen hanging ratio. If the netting has been cut from larger sheets, one or two selvedge rows (guarding) with thicker twines (210/12 den) should be braided along the upper and lower edge of the netting.

With respect to hanging lines, different practices are used. The netting can be hung directly on the float- and leadlines (framelines) or extra hanging lines can be used. If double framelines are used (S- and Z- laid), as for the chosen floatline for the herring driftnet, one of these should be used to hang the netting on. In case of an extra hanging line it is always of thinner material than the frameline.

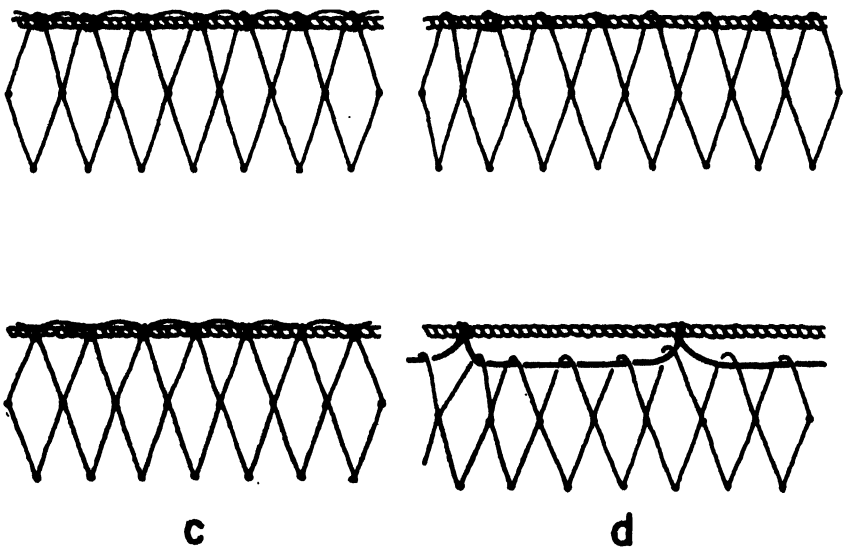


Fig. 20 Illustration of hanging of netting

The mounting of the netting to the hanging line can be done in different ways. One practical and simple way is shown in Figure 20 (a) and (b). Here the hanging line is threaded through the last row of meshes (selvedge row) of the netting. Before attaching the netting, the distance between the attachment points must be calculated according to the actual mesh size and the decided hanging ratio. This will depend on whether every mesh is tied to the hanging line (Figure 20 (a), or whether the meshes in between will hang loose on the hanging line as shown in Figure 20 (b).

Example: Calculation of the distance between the attachment points (L_f), when:

Mesh size	Lm = 5.5 cm
Hanging ratio	E = 0.65
No. of meshes between attachments	N = 4

L_f = Lm.E.N = 5.5 x 0.65 x 4 = 14.3 cm

Another method is to use extra hanging line which is threaded into the last netting row, then attached to the frameline, as described and shown in Figure 20 (d), or as shown in Figure 20 (c) attaching each mesh with twine to the frameline, without threading the frameline through the meshes.

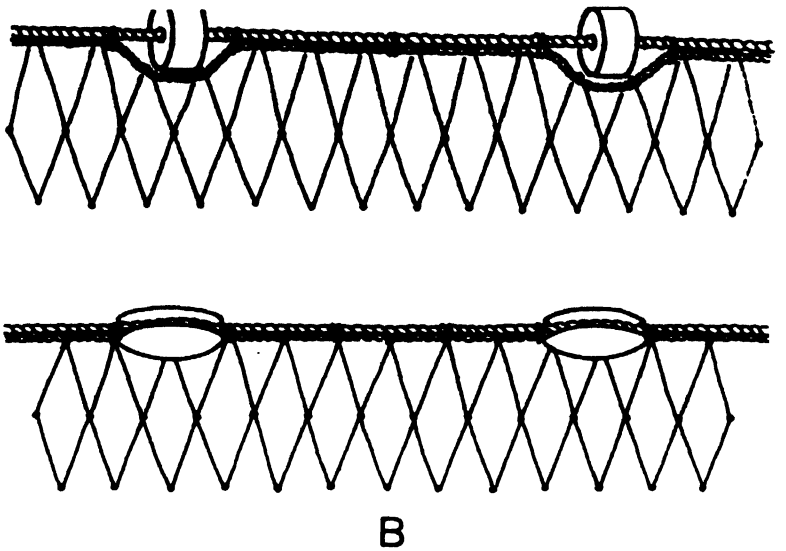


Fig. Different ways of float attachment

The attachment of the hanging line to the other part of the frameline has to be planned and performed according to the actual shape and type of floats and how the float is to be attached, as shown in Figure 21. Figure 20 (a) shows a proper way of attaching the floats and netting to the floatline for a herring driftnet. The floats are thread on the floatline, while the last netting row is thread onto another line (hanging line). When performing the attachment it is advisable to stretch freely a considerable length of the ropes (if there is enough space). The attachment points can then be measured and marked on the ropes over the stretched length, and the actual number of meshes between each mark distributed. Alternatively, the distance between each attachment can be measured by means of a mark pin successively during the attachment.

When using centre-hole floats, as illustrated in Figure 21, it is not necessary to tighten them to the ropes by means of extra ties. By this way of attachment, therefore, the same ties have both the function of netting and float attachment, and to tie the two floatline ropes together.

Figure 21 (B) shows how a float with grooves is fastened. Here the ties between the two ropes, which with this type of float should have equal dimensions, must be tight to either side of the float to fasten it properly.

The attachment of the netting to the leadline is principally the same as for the floatline (with centre-hole floats). The advantage of using the chosen leadedrope for the herring net is a more simple attachment and more even ballasting. The last row of netting (guarding) is thread onto the hanging line and the attachment between the hanging line and the leadedrope is made the same way as that of the floatline.

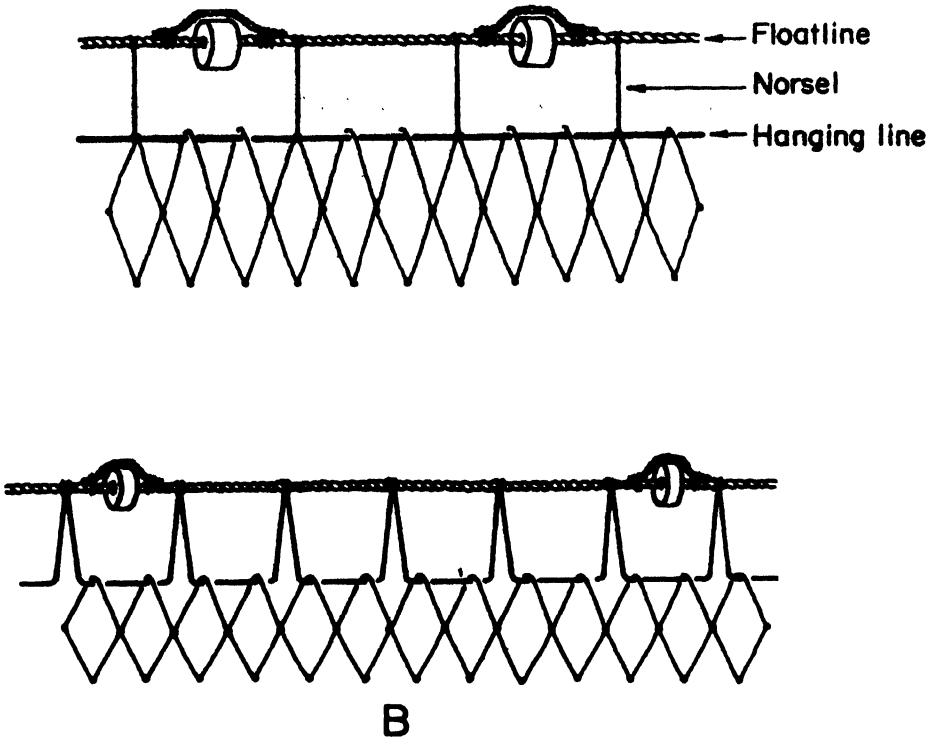


Fig. 22 Driftnets with norsels

For heavier driftnets where big catches may occur, the hauling strain on the netting may be reduced by separating the hanging line on the float- and leadrope by means of norsels, as shown in Figure 22 (a). Another advantage is that the netting will be less entangled with the framelines, when shooting or hauling the nets or under bad weather conditions. This has been a common practice in offshore herring fisheries, and a similar arrangement has been developed for bluefin tuna driftnets, as shown in Figure 22 (b).

5.3 Preparing a Fleet

Preparation of a fleet of driftnets includes joining of the single nets and rigging the fleet with buoys, buoylines, markers and finally leader rope.

As the use of leader ropes is not so relevant in small-scale fisheries, it is left out of the further description.

5.3.1 Joining the nets

The driftnets in a fleet are joined by tying the floatlines and leadlines of one net to the similar lines of the subsequent net. In order to make the joining easier, the extension of the lines at one side of the single nets may be spliced into an eye or tied with an easily released knot as shown in Figure 23 (A). The nets should be tied close together so the netting at the lines of the two nets almost touch. For clupeid driftnets it is not necessary to lace the gavel lines together. However, in

other driftnet fisheries as for instance salmon, this is common and necessary to prevent the salmon from passing between the nets (see Figure 23 (b)). The advantage of not tying the gavels together (Figure 23 (a)) is a quick replacement of a torn or damaged net, but the disadvantage is that the fish which have visually observed the net might swim along side it and eventually escape between the gavel lines.

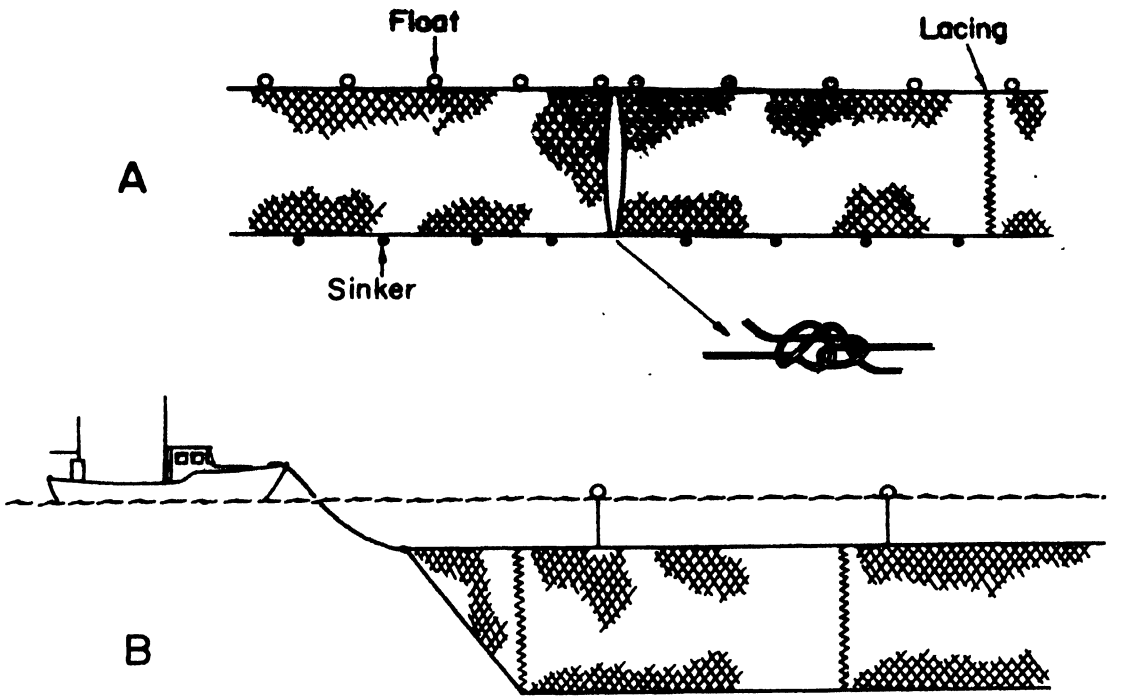


Fig. 23 Joining of driftnets and connection to vessel

5.3.2 Connection to the vessel

Fleets of clupeid driftnets should be connected to the vessel when they are fished. The connection is generally by a leaderope extended from the floatline of the last net in the fleet, or in the case of the Scottish method, to the leadline of the last net in the fleet.

There is little requirement to the thickness of the leaderope and its length and strength should be chosen according to the conditions of fishing, with regard to weather, current and presence of other vessels.

Figure 23 (b) also shows how a bridle or a barcut netting could help to ease the drifting force of the vessel on the fleet of nets.

5.4 Strops, Buoyropes, Buoys and Marker Dhans

A fleet of driftnets also must be prepared with buoyropes (strops) and buoys. The purposes of these fleet components are to:

- keep the nets at the desired depth,
- mark the fleet (for other vessels),
- indicate catch,
- prevent the nets from sinking after heavy catch.

Even surface driftnets with an abundance of float capacity should be supplied with buoys to make the fleet easier to detect and prevent it from sinking with heavy catches. In fisheries with small catches, the need for extra buoyancy is not valid and the only purpose for buoys on surface nets is to serve as markers (marker dhans) and as a warning to other vessels.

5.4.1 Number of buoys

The actual number of buoys or marker dhans on driftnets may vary from one every fifth net (surface driftnets) to several on each net. For midwater nets hanging directly from the surface, as is the case for some herring driftnets of 43 m length, one or two buoys per net is advisable.

5.4.2 Buoyropes or strops

There are no special requirements for the buoyropes other than that they should have a certain breaking strength (from 100 kg and upward) and not to be too difficult to handle: any type of thin rope from about 2 mm to 8 mm in diameter can be used. A 5-mm rope is sufficient for herring driftnets.

The length of the buoyropes should be carefully chosen in relation to the vertical migration of the fish. No general advice can be given for clupeid nets, except that in most conditions they would be in the range from about 0.5 m to about 20 m.

5.4.3 Buoys

The surface buoys should neither be too large nor too small. They should have enough buoyancy to prevent the nets from sinking even with heavy catches. On the other hand, if they are too large they will not so easily indicate (the weight of) fish caught in the nets.

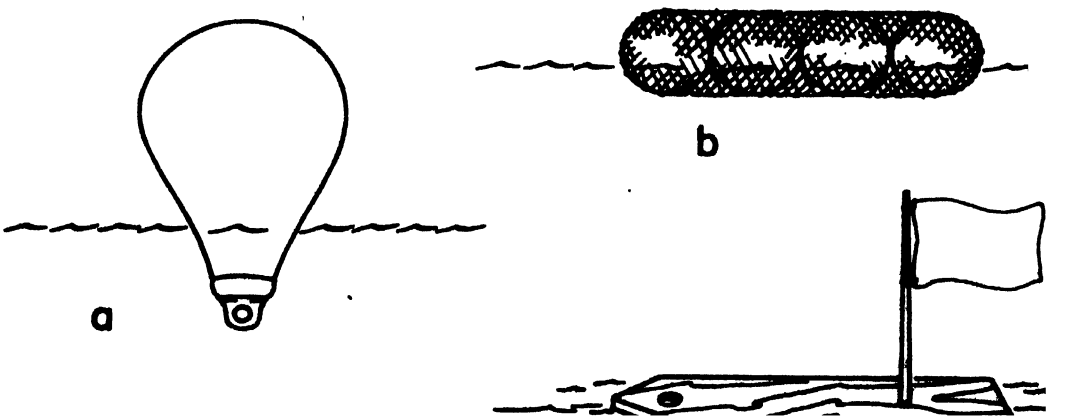


Fig. 24 Different types of surface buoys

The type of floats used can and should be chosen according to the availability. Airfilled plastic floats (Figure 24A) have a good buoyant capacity in relation to their weight, and they are produced in any size from a few up to several hundred kilogrammes buoyancy. Their disadvantage is that they are expensive. Empty plastic cans made for the distribution of oil or other liquids are cheap and therefore popular floats in many driftnet fisheries.

Other more traditional types of floats are (bundles of) glass balls and wood kegs of different forms and sizes or solid wood or cork (marker) buoys. Some examples of such buoys are shown in Figure 24, (b) and (c).

6. DETAILED TECHNICAL DRAWINGS OF DRIFTNETS FROM VARIOUS WELL-KNOWN DRIFTNET FISHERIES.

On the following pages, detailed drawings of driftnets from various well-known driftnet fisheries are given.

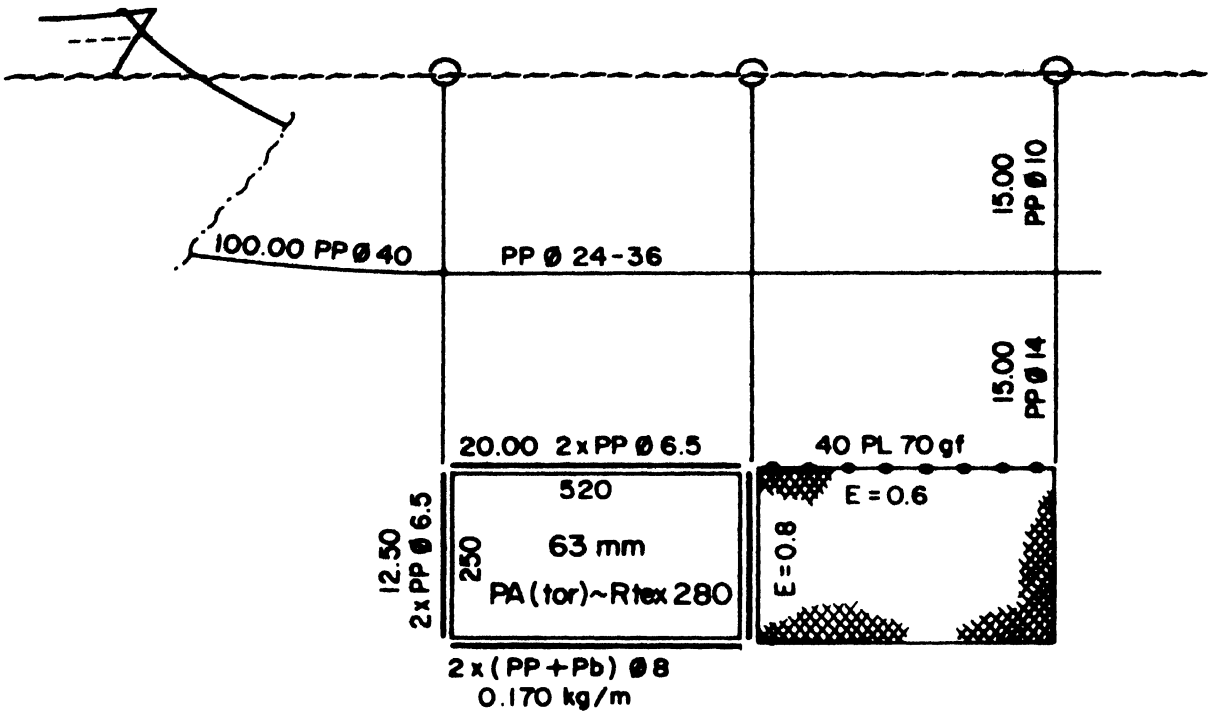


Fig. 25.a - Icelandic herring driftnet

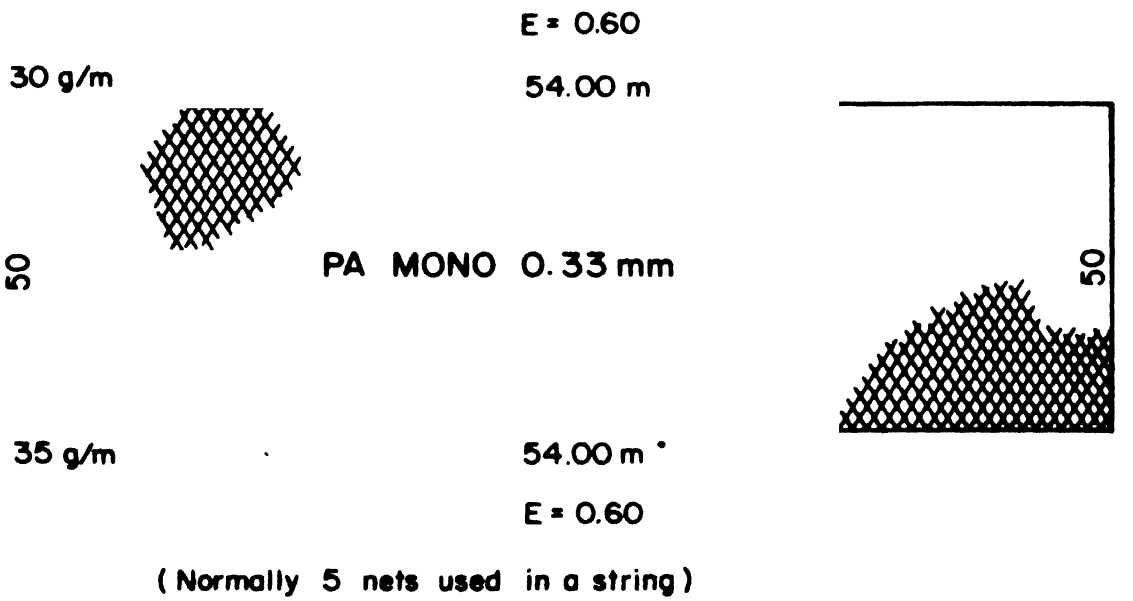
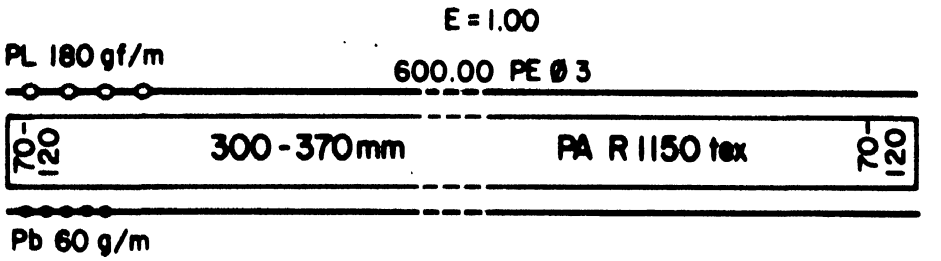


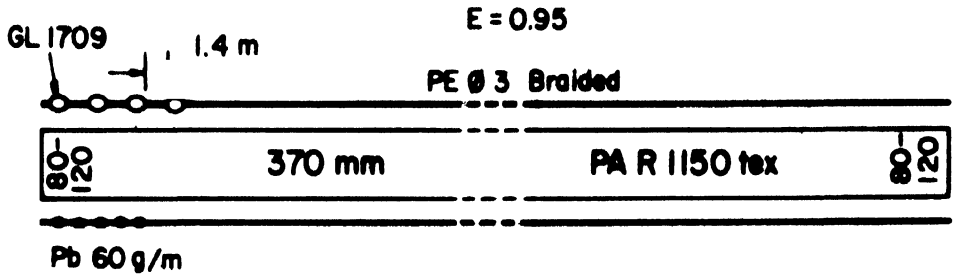
Fig. 25.b - El Salvador's bottom driftnet for shrimp

DRIFTNET FOR SWORDFISH (ADDITIONAL CATCHES TUNA AND SHARKS)
AREA MEDITERRANEAN
COUNTRY ITALY



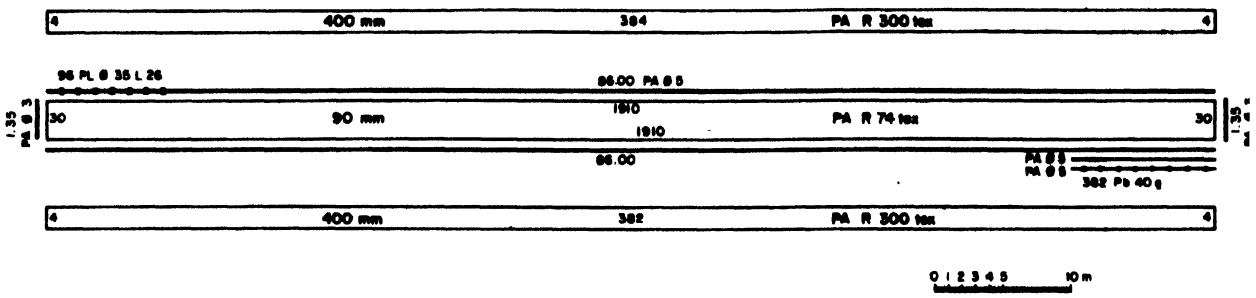
Each boat 10-20 nets or fleet of 6-12 km. At least one large marker buoy at each net. Floatation / ballast ratio 3:1.

DRIFTNET FOR SWORDFISH (ADDITIONAL CATCHES TUNA AND SHARKS)
AREA MEDITERRANEAN
COUNTRY ALGERIA



Each boat carries a fleet of nets up to 15 km long, with large marker buoys at regular intervals.

Fig. 26 - Driftnet for swordfish
Area Mediterranean



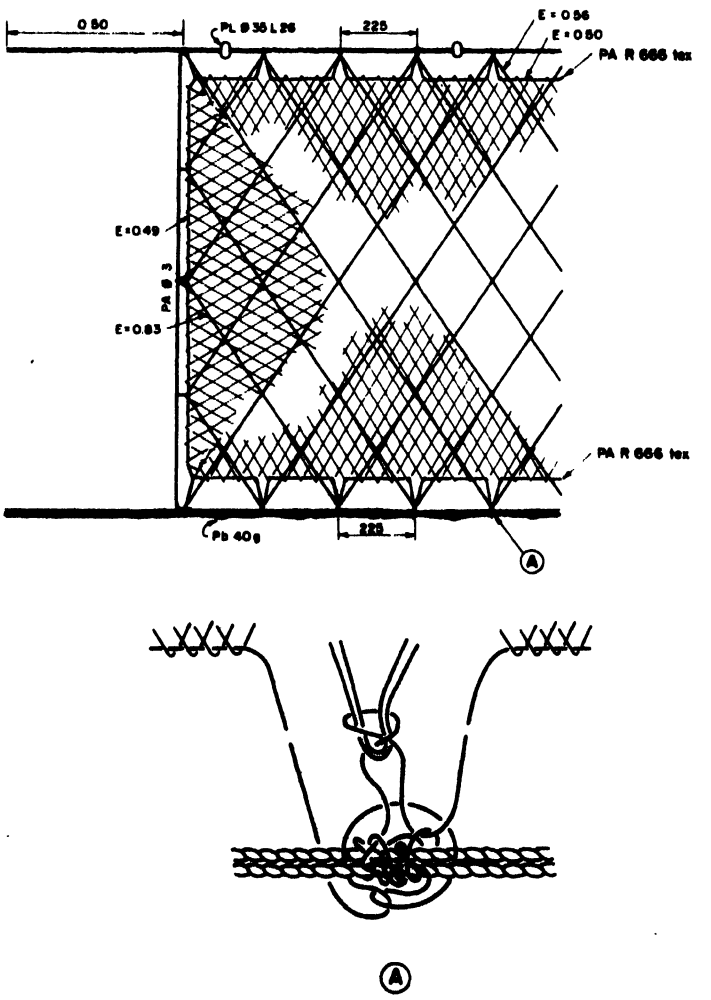


Fig. 27 - Trammel net bottom set for sole Mediterranean, France

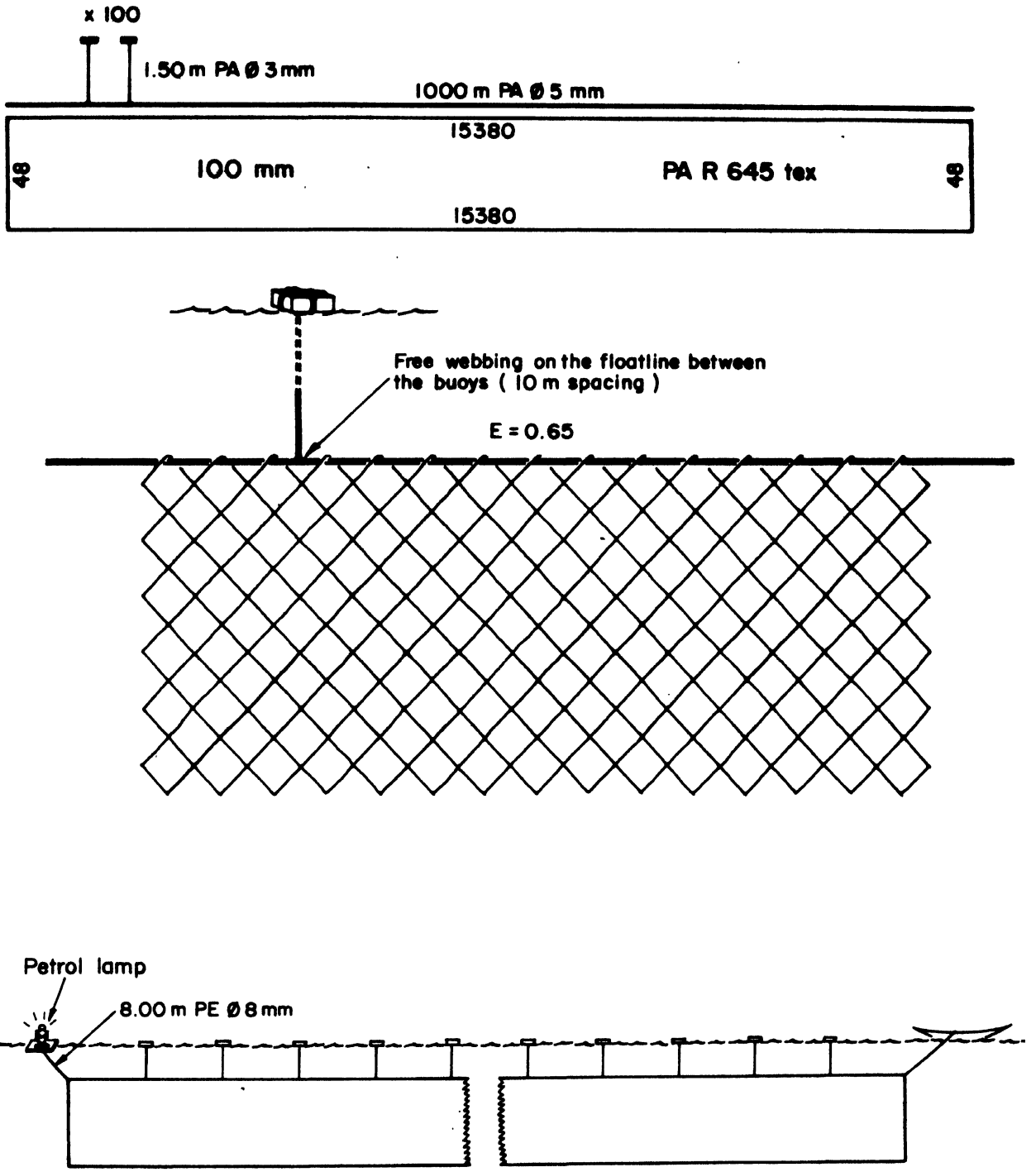
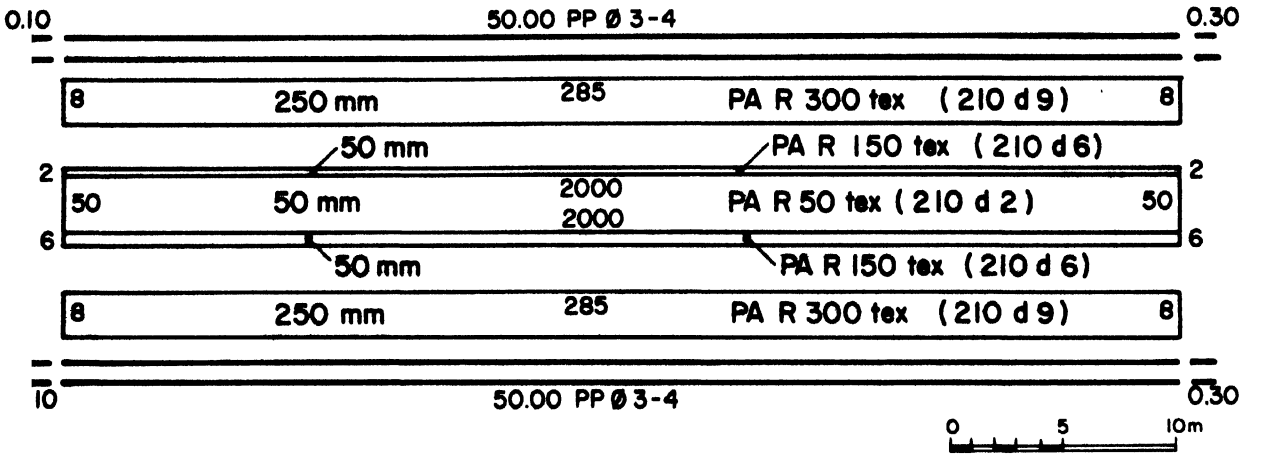
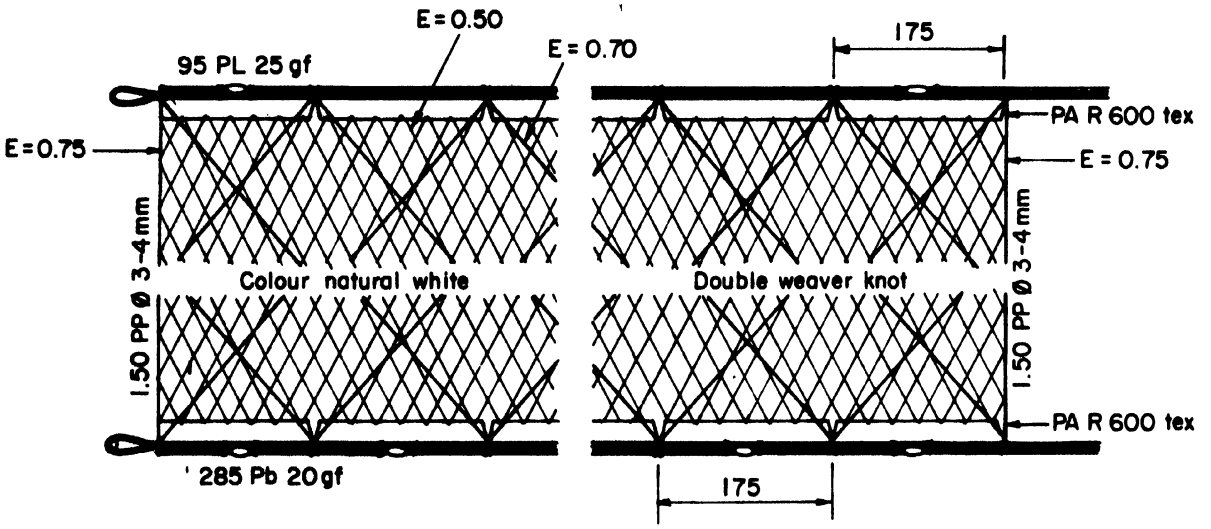

x 100
1.50 m PA Ø 3 mm
1000 m PA Ø 5 mm
15380
100 mm
PA R 645 tex
15380
Free webbing on the floatline between the buoys (10 m spacing)
E = 0.65
Petrol lamp
8.00 m PE Ø 8 mm

Fig. 28 - Drifting gillnet without leadline for catching of threadfin, bream, bass and catfish. Country Japan





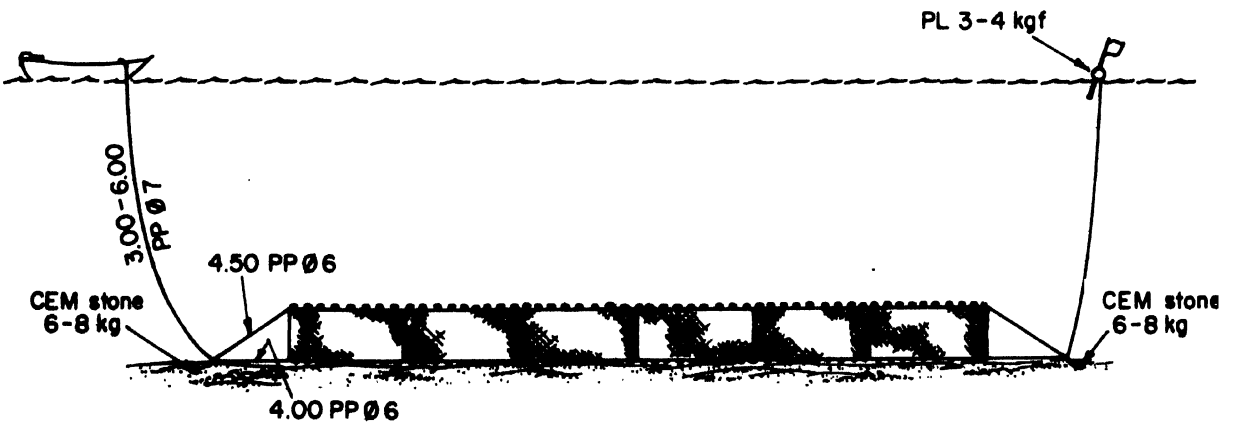


Fig. 29 - Country: Sri Lanka. Entangling net. Trammel bottom set or drifted for shrimp

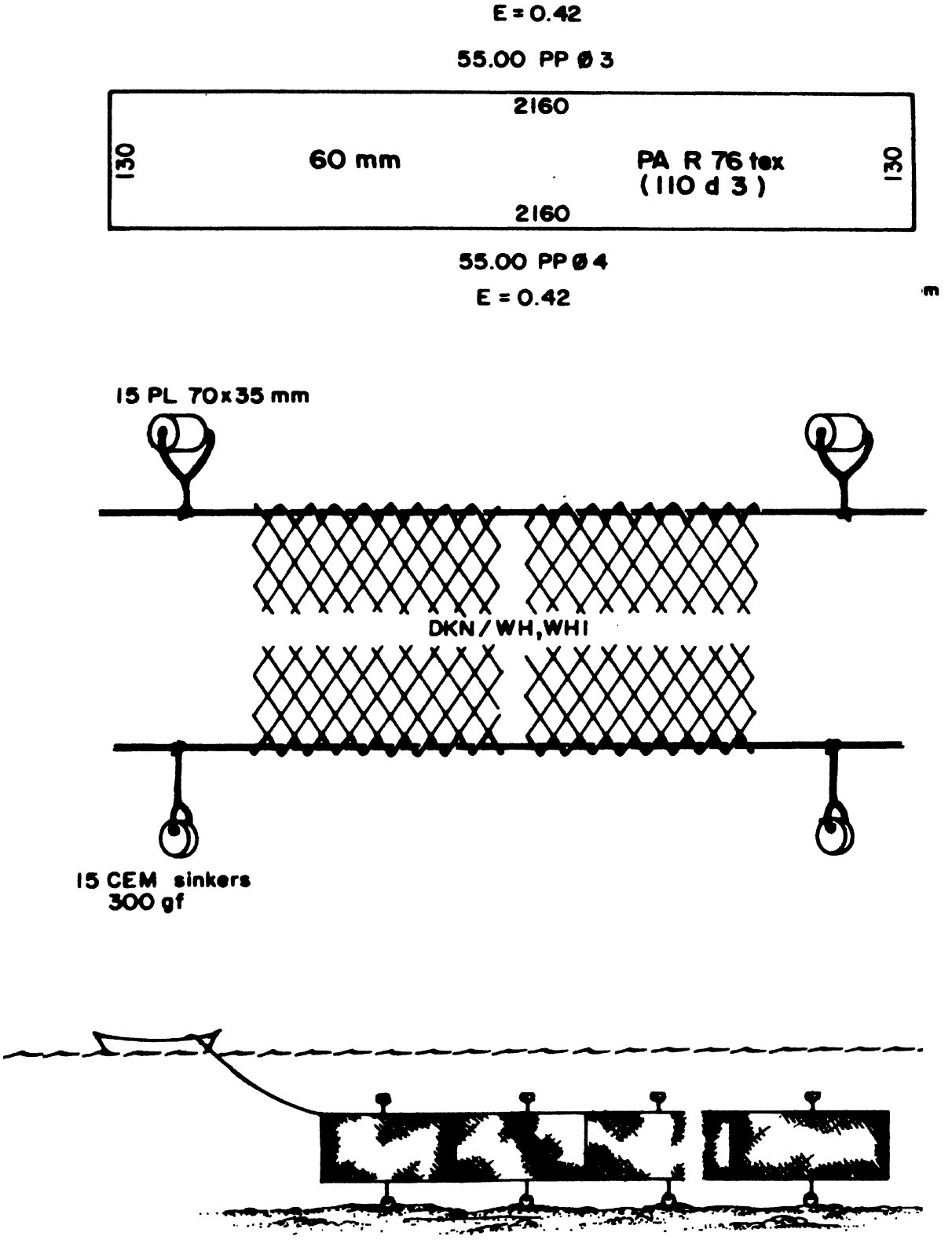


Fig. 30 - Country: India. Bottom driftnet for prawns

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